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Burro Creek Watershed
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Final Report

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FINAL REPORT

WATER QUALITY STUDY
BURRO CREEK WATERSHED, ARIZONA

Ambient Water Quality Unit
Bureau of Water Quality Control
Division of Environmental Health Services
ARIZONA DEPARTMENT OF HEALTH SERVICES
Phoenix, Arizona
February, 1984

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FINAL REPORT

WATER QUALITY STUDY
BURRO CREEK WATERSHED, ARIZONA

Prepared by:
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Phoenix, Arizona
February, 1984

Funded by:
USBLM Contract No. AA851-CT1-70

Manager, Ambient Water Quality Unit	Acting Manager, Water Quality Management Section	Chief, Bureau of Water Quality Control

ABSTRACT

The Arizona Department of Health Services conducted an intensive water quality survey of the Burro Creek drainage from February, 1982 through February, 1983. Work was performed under contract to the U.S. Bureau of Land Management. The survey was designed to characterize water chemistry and assess the suitability of water in the drainage for a number of specific uses, including drinking water, native fisheries protection, livestock watering, and riparian habitat maintenance. Also examined were the specific effects of grazing and current and historic nonferrous metals mining (principally copper) on water quality. Thirty-five sampling sites were established in the drainage, including sites on Burro Creek, Francis Creek, Boulder Creek, Wilder Creek, Copper Creek, and sites monitoring springs and alluvial groundwater. Limited numbers of sediment and fish tissue samples were collected for heavy metals analyses.

Burro Creek and Francis Creek were the only two permanently flowing streams in the drainage, the remainder being ephemeral/intermittent. These two creeks had much higher summertime dissolved oxygen levels than other waters in the drainage, a condition that was attributed to continuous streamflow. Thermal springs in Francis Creek were a primary source of flow for downstream reaches of Burro Creek and contributed significant nitrate nitrogen loads to the system. Little evidence of adverse effects of grazing on water quality were noted in Burro Creek or Francis Creek. Boulder Creek's waters were severely polluted by acid, sulfate, and a variety of heavy metals in the vicinity of the abandoned Hillside Mine. Two distinct sources of pollution were noted in this area. Iron, manganese, copper, zinc, arsenic, and aluminum were the most abundant metals in the polluted waters; cadmium, zinc, and manganese were the most mobile metallic contaminants. Boulder Creek water was much improved in quality when it reached Copper Creek, three miles downstream of the Hillside Mine. Cyprus-Bagdad Copper Company's improvements

in the Copper Creek drainage have led to significant improvements in the quality of Boulder Creek, although surface and alluvial waters in Copper Creek were of suboptimal quality. Boulder Creek had a recognizable effect on the quality of Burro Creek, elevating its levels of fluoride and sulfate. Burro Creek's water quality was unaffected by a USBLM campground located on its banks.

Sediment sampling confirmed the deposition patterns for heavy metals and sulfates observed in surface water samples. Sampling for waterborne radionuclides indicated that the abondoned Hillside Mine was a potentially significant source of radiation to the downstream ecosystem. Fish and frog tissue samples showed higher levels of metals downstream of sources at the Hillside Mine than upstream.

Overall water quality in Burro and Francis Creeks above the Boulder Creek confluence was judged to be excellent. Water quality in the Boulder Creek drainage was poor, particularly in summer, due to pollution from the Hillside Mine, naturally occurring fluoride, and low dissolved oxygen concentrations. Water quality in Burro Creek below Boulder Creek was good, although fluoride and sodium levels made this water less than optimal as a long-term drinking water source. Recommendations are made in the report as to future water quality management practices and opportunities for further research.

All intensive survey data are available through USEPA's STORET computerized data base. Data sheets are on file at ADHS and the USBLM Phoenix District Office.

Keywords: Water quality; water pollution; Arizona; Burro Creek; Boulder Creek; Francis Creek; grazing; copper mining; abandoned mining; heavy metals; nutrients.

ACKNOWLEDGEMENTS

Funding for this project was provided by U.S. Bureau of Land Management Contract AA851-CT1-70. This document is intended to fulfill the contract requirement for a final intensive survey report.

The author would like to thank the many people whose assistance made the timely completion of this project possible. Field assistance was provided by Ed Swanson, Timothy Love, and John Shepardson of Arizona Department of Health Services, Sonja Hoppe and Don Buckley of the Arizona Game and Fish Department, Ted Cordery of USBLM, and Phil Blacet of Cyprus-Bagdad, Copper Corp. The author wishes to extend particular thanks to Justin Turner of Water Resources Associates, and Bill Kepner and Dan McGlothlin of USBLM Phoenix District Office in this regard. Dr. Donald Runnells of the University of Colorado, who served as consultant to Cyprus-Bagdad, is gratefully acknowledged for sharing quality control data, for aiding in geochemical interpretation and for reviewing the draft manuscript. ADHS Laboratory Service personnel, notably Barbara Olivieri and her staff, and Jerry Williams, deserve special mention for their consistently excellent work in performing laboratory analyses. Tom Bradbeer and Myra Nicholson were responsible for STORET data entry and management; maps and figures in the text were prepared by Steve Ellingson and Brad Mueller. Lastly, the author wishes to thank Barbara Turley, Mary Day, Mildred Langdon, and other ADHS clerical staff personnel for the preparation of this document.

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INTRODUCTION

This report was prepared in fulfillment of a U.S. Bureau of Land Management contract, the purpose of which was to characterize the quality of water resources in the Burro Creek drainage, identify the sources and severity of water pollution, and determine the suitability of area waters for various beneficial uses. Also included are management recommendations for specific problems. Field work for the project was begun in February 1982, in the form of a background survey, upon which the intensive survey design was based (Rampe, 1982b). The intensive survey was begun in April, and sampling continued on a bimonthly basis until its conclusion in February, 1983. A sampling trip was made in January, 1983, for the express purpose of collecting stream sediments.

The report discusses water chemistry and sediment data gathered during the background and intensive survey for nutrients, heavy metals, radionuclides, bacteria, and general physicochemistry. Variations in chemical behavior are described with respect to changes in discharge and other seasonal cycles. The mechanisms and patterns of heavy metal distribution from various sources are discussed in detail. Water chemistry characteristics have been compared with Arizona State surface water quality standards, U.S. Environmental Protection Agency criteria, and other recognized or suggested criteria to determine these waters' suitability for various uses (Table 1). These uses are domestic water, livestock water, native fisheries maintenance, riparian habitat maintenance, and full body contact recreation. All of these uses currently exist in the drainage. The protected uses recognized in State standards for surface waters in the drainage are partial body contact recreation (Burro Creek only), aquatic and wildlife, livestock watering, and agricultural irrigation (Boulder Creek only).

Table 1. Arizona State surface water quality standards, USEPA and other recognized criteria for beneficial uses of concern in the Burro Creek watershed. d-dissolved; t-total

Parameter	Recreation	Aquatic life protection			Domestic water		Livestock	Riparian protection
	Arizona	Arizona	USEPA	Other	USPHS, 1962	Arizona	Arizona	Arizona
Al	-	-	-	0.5	-	-	-	-
Ag	0.05d	0.05d	0.013t	-	0.05t	0.05d	-	-
As	0.05d	0.05d	0.44t	-	0.01t	0.05d	0.20t	2.00t
Bacteria, fecal coliform	800	4,000	-	-	-	4,000	4.000	4,000
Cd (maximum cfu)	0.01t	0.01d	0.006t	0.006d	0.01t	0.01t	0.05t	0.05t
Cl	-	-	-	170	250	-	-	-
Cr	0.05d[5]	0.05d[5]	1.26t[6]	0.05t[6]	0.05t[6]	0.05d[5]	1.00t[5]	1.00t[5]
Cu	-	0.05d	0.043t	-	1.00t	1.00d	0.50t	5.00t
F	-	-	-	1.5	0.8-1.7[7]	-	-	-
Gross alpha + beta, pCi/l[9]	30	-	-	-	-	-	-	-
Mn	-	-	-	0.1-1.0t	0.05t	-	-	10t
Na	-	-	-	-	100[8]	-	-	-
Ni	-	-	3.10	-	-	-	-	-
No_3-N	-	-	-	5.0	10	-	-	-
O_2(minimum)	6.0	6.0	5.0	-	-	-	-	-
Pb	0.05d	0.05d	0.40t	0.05t	0.05t	0.05d	0.10t	1.00t
pH	6.5-9.0	6.5-9.0	6.5-8.5	-	-	-	6.5-9.0	4.5-9.0
Ra-226 + 228, pCi/l[9]	5	-	-	-	-	-	-	-
Sb	-	-	1.6	-	-	-	-	-
Se	0.01d	0.05t	0.760t	-	0.01t	0.01d	0.05t	0.02t
SO_4	-	-	-	90	250	-	-	-
TDS	-	-	-	400	500	-	-	-
Zn	-	0.50d	0.57t	0.10t	5.0d	-	25.0t	10.0t

1. State surface water quality standard for full body contact recreation, criteria for partial body contact do not exist for most parameters; 2. Criteria from USEPA, 1976 and 1980 a-j, hardness set at 200 mg/l $CaCO_3$; 3. References include AFS (1979), McKirdy (1968), Dawson (1974), Davies and Goettl (1977), and Hunter, et al, 1980; 4. State surface water quality standard for agricultural irrigation water; 5. Hexavalent plus trivalent Cr; 6. Hexavalent Cr only; 7. Varies according to average annual air temperature; 8. Reference - NRC (1977); 9. General standard applicable to all State surface waters regardless of designated uses.

Also included in this report are a description of the intensive survey study area, derived largely from previous USBLM studies, a history of previous water quality investigations in the drainage, a materials and methods section, and a brief final overview. The discussion of sampling results has been geographically divided into three separate sections. These sections are: Francis Creek and upper Burro Creek, Boulder Creek and tributaries, and lower Burro Creek, at and below its confluence with Boulder Creek. Sites within each of these areas tended to be homogeneous with regard to water quality management concerns and, to a certain extent, water chemistry characteristics. Each of these three sections ends with a "Summary and Conclusions" subsection, wherein may be found a synopsis of important findings and recommendations generated by the intensive survey. It is hoped that the utility of this document to readers of various technical backgrounds will have been improved by reason of this organizational scheme.

MATERIALS AND METHODS

Samples for major ion, trace element and radiochemical analyses were collected in one-liter acid-washed polyethylene bottles and preserved with concentrated nitric acid. Nutrient samples were collected in similar containers and preserved with concentrated sulfuric acid. Orthophosphate samples were filtered (Millipore 0.45 um pore size acetate filters) on site and placed in 100 ml polyethylene bottles without preservative. Turbidity and alkalinity samples were taken in unpreserved containers. All unpreserved samples and those containing sulfuric acid were iced in the field.

Samples for dissolved metals were generally filtered on site using Millipore 0.45 um pore size acetate filters. Flood samples for trace element analysis were placed on ice and delivered to the ADHS laboratory for filtration. This pore size allowed the passage of dissolved metals as well as some colloidal precipitates (Kennedy, et al., 1974), but in this paper metals found in filtered samples will be treated as if present wholly in dissolved form. A stainless steel spoon was used to collect sediment samples, which were transported in plastic bags. All sediment samples were aggregates of several grab samples taken at each site. Only particle size fractions smaller than 250 um were used for analysis. Tissue specimens were taken from fish and frogs collected by backpack electroshockers and flash frozen in the field with dry ice. All samples were delivered and subsequently analyzed within USEPA recommended holding times. Bacterial samples were collected in sterile bags and filtered in the field. They were placed on MVFC holding media, iced and delivered to the ADHS laboratory for culture and enumeration.

Field measurements included water temperature, dissolved oxygen, specific conductance, pH, and flow. Temperature and dissolved oxygen were measured with a YSI 54 oxygen meter, specific conductance was determined using a Hach 16300

portable meter, and pH was measured with a Digisense portable meter. Discharge was calculated by measuring velocity with a Marsh-McBirney model 201 portable flow meter along a transect according to the method of Schulz (1976). Subsurface discharges were estimated by analyzing major ion loadings as described by Hendrickson and Krieger (1964) and Rampe, et al., (1981).

A list of analyses performed by ADHS, Arizona Game and Fish Department Laboratories and Controls for Environmental Pollution, Inc., methods employed, and references is provided in Table 2. ADHS laboratory detection limits for nutrient and trace element analyses are given in Table 3.

Both internal and external quality control procedures were followed to insure the validity of analytical data. As a matter of routine, ADHS laboratories ran approximately 10% internal control samples for each analysis. Control charts were kept to determine analytical accuracy and precision (APHA, 1981). Spiked samples containing known concentrations were submitted periodically during the sampling period by the quality control division of ADHS laboratories to check laboratory accuracy. Quality control samples were collected by ADHS field personnel and submitted to ADHS laboratories; quality control samples were also collected by Dr. Donald Runnells of the University of Colorado under the auspices of the Cyprus-Bagdad Copper Corporation. These latter samples were analyzed by Coors Laboratories in Golden, Colorado and at the University of Colorado, Boulder. Thirty quality control samples (19% of the total number collected during the background and intensive surveys) were taken, twenty-one by Dr. Runnells and nine by ADHS personnel. Results of quality control samples agreed well with those obtained for field samples and are summarized in Appendix B.

All sample results were checked before being accepted, and questionable results were subjected to reanalysis. Such factors as consistency of data with information

Table 2. Analyses performed and methods used to generate Burro Creek Intensive Survey data.

Parameter (Agency performing analysis)	Method of Analysis	Standard Methods (APHA et al., 1981) Reference Number; Page or Citation
Water (Arizona Department of Health Services)		
pH	meter, glass electrode	423; p. 402
Conductance	meter, platinum electrode	205; p. 70
K, Fe, Li, Mg, Mn, Na, Ni, Si, Zn	flame atomic absorption by direct aspiration	303A; p.152
Bicarbonate and carbonate alkalinity	potentiometric titration	403; p. 253
Hardness	EDTA titration	314B; p. 195
Chloride	specific ion electrode	407C; p. 273
Sulfate	barium choride, turbidimetric	426C; p. 439
Fluoride	specific ion electrode	413B; p. 335
Ag, As, Co, Cr, Cu, Mo, Sb, Se (Note 1)	graphite furnace atomic absorption	304; p. 166
Hg	cold vapor atomic absorption	303F; p. 164
Cd, Pb	flame atomic absorption after MIBK	303B; p. 156
Al	flame atomic absorption by direct aspiration	303C; p. 157
NO_2+NO_3-N	cadmium reduction autoanalysis	418F; p. 376
NO_2-N	sulfanilamide, NEO-dihydrochloride	419; p. 380
Kjeldahl N	Kjeldahl digestion	420A; p. 383
PO_4-P(total)	persulfate digestion; ascorbic acid - ammonium molybdate	424C; p. 414 424F; p. 420

Parameter (Agency performing analysis)	Method of Analysis	Standard Methods (APHA et al., 1981) Reference Number; Page or Citation
PO_4-P(ortho)	0.45um filtration; ascorbic acid - ammonium molybdate	424F; p. 420
Turbidity	nephelometric	214A; p. 132
Filterable residue	gravimetric, 103-105°C	209B; p. 93
Suspended solids	gravimetric, 103-105°C	209D; p. 94
Fecal coliform bacteria	membrane filter; M-FC medium	909C; p. 814
Sediment (Arizona Game and Fish Department)		
%moisture	gravimetric, 103-105°C	
%sand, silt, clay	Tyler sieves and hydrometer	ASTM, 1980a
Al, As, Cd, Cu, Fe, Mn, Sb, Zn	atomic absorption by direct aspiration of fraction passed through #60 Tyler sieve and extracted with nitric-perchloric acid	Van Loon, 1980a; Pinta, 1978
SO_4	Turbidimetric after ammonium acetate extraction	Black, 1965
Tissue (Arizona Game and Fish Department)		
As, Cu, Mn, Sb, Zn	atomic absorption by direct absorption of fraction passed through #60 Tyler sieve and extracted with nitric-perchloric acid	Van Loon, 1980b; Christian and Feldman, 1970

Table 2, cont.

Parameter (Agency performing analysis)	Methods of Analysis	Standard Methods (APHA et al., 1981) Reference Number; Page or Citation
Radiochemistry (Controls for Environmetal Pollution, Inc.)		
Gross alpha and gross beta	internal proportional counting	703; p. 574
Total U	fluorometry	ASTM, 1980b
Radium - 226	radon in water	706; p. 590
Radium - 228	sequential method radium-228/radium-228	USEPA, 1975

Note 1. The method of analysis for Ag changed from direct aspiration to graphite furnace atomic absorption on 22 June, for Cr on 21 June, and for Cu on 17 August.

Table 3. Arizona Department of Health Services detection limits for trace elements and nutrients monitored in the Burro Creek

Parameter	Detection limit (mg/l)
Al	.5
Ag	.05/.005 (Note 1)
As	.02
Cd	.005
Co	.01
Cr	<.05/.01
Cu	.05/.01
Fe	.05
Hg	.002
Li	.1
Mn	.05
Mo	.01
Ni	.1
Pb	.02
Sb	.01
Se	.005
Zn	.05
NO_2-N	.01
NO_2+NO_3-N	.1
Kjeldahl N	.2
PO_4-P (total)	.03
(ortho)	.01

Note 1. Limits decreased as analysis was changed from direct aspiration to graphite furnace atomic absorption.

from previous samplings and internal data consistency (such as between pH and dissolved metals concentrations) were considered in deciding whether or not to accept laboratory data. Field pH and specific conductance values were reconfirmed by laboratory analysis. While field and laboratory values for these two parameters generally agreed well, laboratory values were used exclusively for interpretation in this report owing to the more sophisticated analytical equipment at ADHS laboratories, and occasional malfunction of field pH meters. Results for dissolved versus total constituents were checked for consistency, that is, to determine whether dissolved values were always less than or equal to total values for a given sample. If dissolved values were higher than total values, both samples were rerun. If the discrepancy was slight, as most were, and persisted after reanalysis, the data were included in the report discussion. Molybdenum analyses were particularly prone to data anomalies of this type.

Major ion results were subjected to charge balance analyses. Results were considered acceptable if anion-cation deviation was less than 10%, as determined by the following:

$$\frac{\text{anions (meq)}-\text{cations (meq)}}{\text{anions (meq)}+\text{cations (meq)}} \times 100\%$$

Large deviations from anion-cation equality were noted in strongly concentrated mine drainage waters. These deviations were attributed to substantial quantities of ions present in these waters that were not normally analyzed for (e.g., H^{+}, Al^{+2}, Sr^{+2}, etc.).

In spite of quality control analyses and data checks, one series of data gathered during the intensive survey was judged to be highly questionable. Total and dissolved phosphate phosphorus levels measured in August were very high (nearly 1.0 mg/l in some cases). Particularly high values were spot checked and confirmed by ADHS laboratories, and this phenomenon was initially interpreted as a watershed-

wide event related to algal senescence. However, further observations on stream productivity at that time, and on phosphorus levels in chemically stable sources such as springs, led to the conclusion that the high August values were artifacts caused by contamination during bottle preparation, sample collection, or analysis. The data have been included in Appendix A, but have not been included in the discussion.

All data except quality control samples have been entered in the STORET water quality data storage and retrieval system. Data were checked twice for errors during entry, and checked twice following storage. All data were coded under agency code 21ARIZ and intensive survey number 820401 for easy retrieval and manipulation.

DESCRIPTION OF THE STUDY AREA

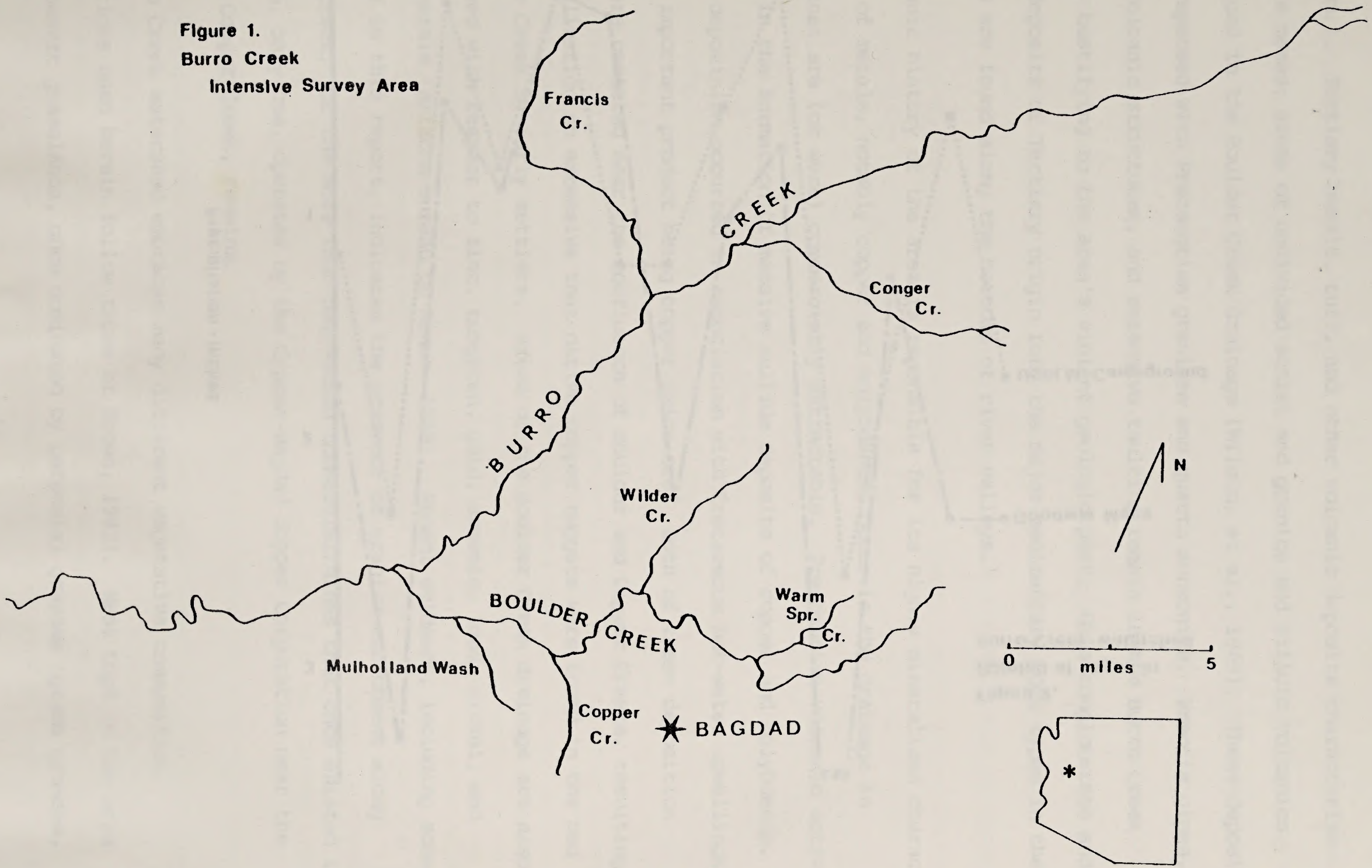
The Burro Creek watershed is located in Mohave and Yavapai Counties, north and west of Bagdad, Arizona (Figure 1). Burro Creek rises in the Luis Maria Baca Float #5, an old Spanish land grant, and flows 57 miles (92 km) southwestward toward the Big Sandy River, a tributary of the Bill Williams River. Along its length it receives the waters of Conger, Francis and Boulder Creeks. Boulder Creek in turn has Copper Creek and Wilder Creek as its major tributaries (Figure 1). Burro Creek rises at 5,310 feet (1,618 m) and meets the Big Sandy at an elevation of 1,510 feet (460 m). The drainage is largely remote except for areas around Bagdad and U.S. Highway 93. Access to much of the watershed is limited to a few unimproved dirt roads.

Average monthly air temperatures near the source of Burro Creek range between 45° and 57° F (7° and 14° C). At lower elevations, average monthly temperatures range from 57° to 67° F (14° to 19° C). During the study, temperatures below freezing occurred in early mornings during December and February, while a high temperature of 113° F (45° C) was recorded in August 1982 near the confluence of Burro and Boulder Creeks in mid-afternoon.

Precipitation amounts vary from a maximum of 16 inches per year near the source of Burro Creek to a minimum of 8 inches per year at lower elevations. Precipitation falls primarily as rain in the area, and manifests the bimodal pattern typical of the Sonoran region. Precipitation falls primarily in late winter-early spring and in mid-to-late summer. Significant rain occured in February and December during the intensive survey. Rainfall records were kept by USBLM at several places in the drainage; these records appear in Figure 2.

The geology of the Burro Creek watershed is complex, manifesting evidence of several distinct periods of vulcanism (Phil Blacet, Cyprus-Bagdad Copper Corporation,

Figure 1.
Burro Creek
Intensive Survey Area



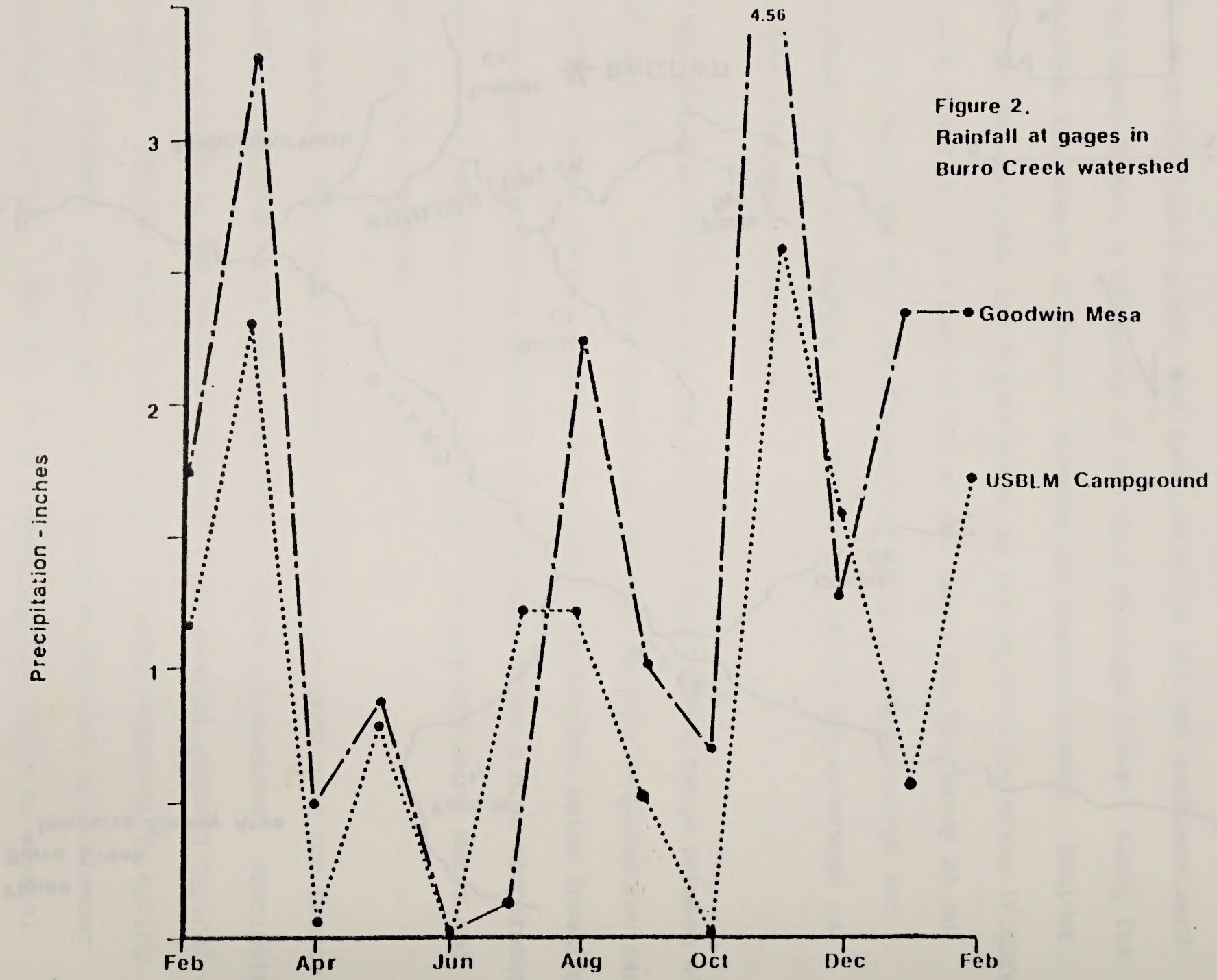


Figure 2.
Rainfall at gages in
Burro Creek watershed

pers. comm.). Tertiary basalt, tuff, and other volcanic deposits characterize the area's mesas; areas of undivided schist and granite and silicic volcanics may be found in the Boulder Creek drainage (Wilson, et al., 1969). These deposits are interspersed with Precambrian granites and quartz monzonite. Breccia pipes, extinct volcanic structures, and extensive faulting remain in the Burro Creek drainage, testifying to the area's violent geologic past. Gila conglomerate and related deposits of Tertiary origin form the major sedimentary rock types in the area, and are found along the bottoms of river valleys.

The volcanic history of the area is reponsible for its highly mineralized character. A number of metals, notably copper and molybdenum, occur in the drainage in amounts that are (or were) commercially extractable. Precambrian volcanic activity resulted in the formation of massive sulfide deposits of copper and molybdenum. A second deposition occurred in association with Cretaceous hot-water upwellings, its most important product being copper oxide ore. Both of these deposition events were centered near the confluence of Boulder and Copper Creeks, resulting in mineralization so extensive that native copper nuggets were found in the bed of Copper Creek by early settlers. Areas of the Boulder Creek drainage are also mineralized with respect to zinc, tungsten, gold, arsenic, lead, nickel, and other minerals (Arizona Bureau of Mines, 1969). Recent evidence, including some generated in this report, indicates the presence of uranium enrichment along Boulder Creek. Of the more than half-dozen commercial mines that once existed in this area, only one, operated by the Cyprus-Bagdad Copper Corporation near the mouth of Copper Creek, remains.

The Burro Creek watershed embraces many different vegetative communities (descriptions used herein follow those of Brown, 1982). Mesa tops in the area are semidesert grasslands, once dominated by perennial grasses (grama grasses,

cottontop, and tobosa), but in many areas reduced to a disclimax state by grazing. Such areas may contain large proportions of winter-spring annual grasses. Area hillsides support diverse plant communities composed of plants characteristic of the Arizona Upland Division of the Sonoran Desert scrub formation. Common members of this community found in the study area include the saguaro (Carnegiea gigantea), prickly pear (Opuntia phaeacantha), barrel cacti (Ferocactus spp.), Christmas cactus (Opuntia leptocaulis), buckhorn cholla (O. acanthocarpa), and pincushion (Mammillaria spp.) and hedgehog (Echinocactus spp.) cacti. Scrub species include ocotillo (Fouquieria splendens), foothills palo verde (Cercidium microphyllum), crucifixion thorn (Canotia holacantha), and jojoba (Simmondsia chinensis). Succulents include yuccas, agaves, and locally, Dudleya sp. At higher elevations in the drainage, elements of the interior chaparral formation appear, notably mountain mahogany (Cercocarpus spp.), sumacs (Rhus trilobata and R. ovata), and cliffrose (Cowania spp.). Juniperus deppeana, characteristic of higher altitude juniper-pinyon woodlands in Arizona, is allowed to exist in these communities by shaded slope aspects and cold air drainage channels. The overall effects of the intergradation of different associations is a very diverse plant community. Two species of plants recognized as significant by Federal agencies occur in the Burro Creek watershed. These are the Burro Creek cliffrose (Cowania subintegra), a U.S. Fish and Wildlife Service candidate for endangered species status, and Bigelow's wild onion (Allium bigelovii), a BLM-listed sensitive species (USBLM, 1983).

Riparian vegetation is characterized by cottonwoods (Populus fremontii), sycamore (Platanus wrightii), Goodding willows (Salix gooddingii), and mesquites (Prosopis spp.). Concern has been expressed regarding the effects of grazing on reproduction of riparian canopy species (Sanchez, 1982). This concern has led to the formulation of grazing plans that would relieve pressure on sensitive allotments (USBLM, 1981).

Field personnel observed abundant regrowth of canopy species at several locations in the watershed, while depauperate riparian communities were found in other areas (see individual discussions). Seepwillow (Baccharis salicifolia) is an important understory component of riparian communities in the drainage, and was particularly important along the braided, sandy runs of the lower portion of Burro Creek. Certain portions of the drainage, notably Black Mesa Gulch, supported a dense riparian scrub association, characterized in this case by mesquites (Prosopis spp.), catclaw (Acacia greggii), desert broom (Baccharus sarothoides), and tree tobacco (Nicotiana glauca), among other, generally thorny, shrub species.

Wildlife in the area is diverse and abundant, owing to the aforementioned richness of topographic and vegetational diversity, and the availability of permanent water. The distribution of vertebrates in the drainage has been extensively documented, mostly under USBLM auspices, in the following reports: Kepner (1979 and 1980), which characterizes aquatic fauna in the Bill Williams and Hassayampa drainages, including the current study area; Jones (1981), which examines the distribution and ecology of local reptiles and amphibians; Millsap (1981), which summarizes the distribution and ecology of raptors in the drainage, with emphasis on possible reproductive stress associated with mine waste pollution; and Hanna, et al., (1976), which provides an overview of both wildlife and vegetation in the drainage. The Burro Creek watershed supports a number of species of wildlife which have received special regulatory designations by State and Federal agencies (Table 4). A partial list of wildlife observed by field personnel would include bald eagle, golden eagle, black hawk, desert tortoise, javelina, mule deer, gray fox, and the leopard frog. Five native fish species were observed and/or collected, including the State-listed roundtail chub.

Table 4. Vertebrate species with special management status occurring in the intensive survey study area.

Species	Agency; status
FISH	
Roundtail chub (*Gila robusta robusta*)	Arizona Game and Fish Department (AGFD); Group III*
REPTILES	
Gilbert's skink (*Eumeces gilberti*)	AGFD; Group II
Desert night lizard (*Xantusia vigilis*)	USBLM; sensitive species
Gila monster (*Heloderma suspectum*)	AGFD; Group III
Desert rosy boa (*Lichanura trivirgata*)	USBLM; sensitive species
Desert tortoise (*Gopherus agassizi*)	AGFD; Group III
BIRDS	
Bald eagle (*Haliaetus leucocephalus*)	Federal endangered list
Golden eagle (*Aquila chrysaetos*)	USBLM; sensitive species
Osprey (*Pandion haliaetus*)	AGFD; Group III
Black hawk (*Buteogallus anthracinus*)	AGFD; Group III
Peregrine falcon (*Falco peregrinus*)	Federal endangered list
Cooper's hawk (*Accipiter cooperii*)	USBLM; sensitive species
Sharp-shinned hawk (*Accipiter striatus*)	USBLM; sensitive species
Zone-tailed hawk (*Buteo albonotatus*)	AGFD; Group III

Table 4., continued

Great egret (*Casmerodius albus*)	AGFD; Group III
Snowy egret (*Egretta thula*)	AGFD; Group III
Black-crowned night heron (*Nycticorax nycticorax*)	AGFD; Group III

*AGFD Group II species are those "in danger of being eliminated from Arizona"; Group III species are those "whose status in Arizona may be in jeopardy in the foreseeable future".

The primary commercial uses of the drainage are mining and livestock grazing. Burro Creek and its tributaries flow through or are adjacent to eight grazing allotments in the study area (USBLM, 1981). About 90% of the land in the study area is publicly owned, being approximately equally divided between the USBLM and Arizona State Land Department. Concentrations of private land in the area are found around the town of Bagdad, and near the confluence of Burro and Boulder Creeks.

HISTORIC WATER QUALITY STUDIES

A great deal of water quality information exists for the Burro Creek watershed, despite the fact that the area is remote. The first known water quality analyses in the drainage were conducted in 1944 by Tim and John Zannaras, local miners who were concerned with the effects of upstream mining operations, notably those at Bagdad, on water quality in Boulder and Burro Creeks. Samples taken in the 1950's and 1960's by the Arizona State Department of Health (forerunner to ADHS), the Bagdad Copper Corporation (forerunner to the Cyprus-Bagdad Copper Corporation), and the Federal Water Pollution Control Agency (later incorporated in the USEPA) showed gross heavy metal pollution in the vicinity of the mouth of Copper Creek. Presumably, this pollution was traceable to Bagdad Copper Corporation discharges. Some of these data also suggested that pollution in Boulder Creek had a measurable effect on downstream water quality in Burro Creek.

Concern over the quality of the Burro Creek watershed led to the formation of a monitoring network by the U.S. Geological Survey (USGS) in the late 1970's. The data generated by this network provided excellent insight into the chemical characteristics of the drainage, but did not differentiate or quantify individual sources of pollution. Sampling conducted by ADHS and the Arizona Game and Fish Department in Boulder Creek in the 1970's was only partly successful in identifying heavy metal influxes.

A water quality emergency took place during the winter of 1978-79 when exceptionally heavy rain forced Cyprus-Bagdad to release water from its copper mining operations in the Copper Creek drainage into Boulder Creek. No data are available regarding the exact chemical composition of this water, which was presumably laden with heavy metals. The Cyprus-Bagdad Copper Corporation attempted to neutralize this water via lime addition, and apparently met with some success. However, the

releases had a serious effect on aquatic communities downstream. Studies by USBLM biologists in conjunction with USEPA and the U.S. Fish and Wildlife Service showed that stream organisms were reduced in number and diversity below Copper Creek, either due to the catastrophic event or to long-term degradation by mine waste from the Copper Creek drainage. Elevated metal levels were found in organisms and sediment below Copper Creek. These metal levels were blamed in turn for phenomena in the downstream watershed directly and indirectly connected with water quality, such as reduced fish diversity and biomass and impaired black hawk reproduction (Kepner, 1979; Millsap, 1981).

Following this incident, the USEPA initiated an enforcement action requiring Cyprus-Bagdad to contain runoff from its heap leach copper recovery operation in Copper Creek by constructing a flood containment structure at the mouth of the creek. Cyprus-Bagdad also commissioned a water quality study performed by Dr. Donald Runnells of the University of Colorado (1982). The study results showed comparatively minor effects on water quality from the improved Cyprus-Bagdad operation in Copper Creek, these effects being primarily increases in sulfate and dissolved solids. The study also showed severe pollution in the vicinity of the abandoned Hillside Mine complex, a source that have been paid little attention in previous work on Boulder Creek.

Little attention has also been paid to other potential water quality problems in the drainage, particularly those presented by overgrazing in streamside allotments. While concerns have been raised regarding the condition of the watershed's riparian vegetation as regards its response to grazing pressure (Sanchez, 1982), few data exist to assess what, if any, effects grazing has had on the instream environment.

A more detailed summary of these historic data was prepared by ADHS for use in planning this intensive survey (Rampe, 1982a). This document also contained the study design upon which the survey was based (see also Rampe, 1982b).

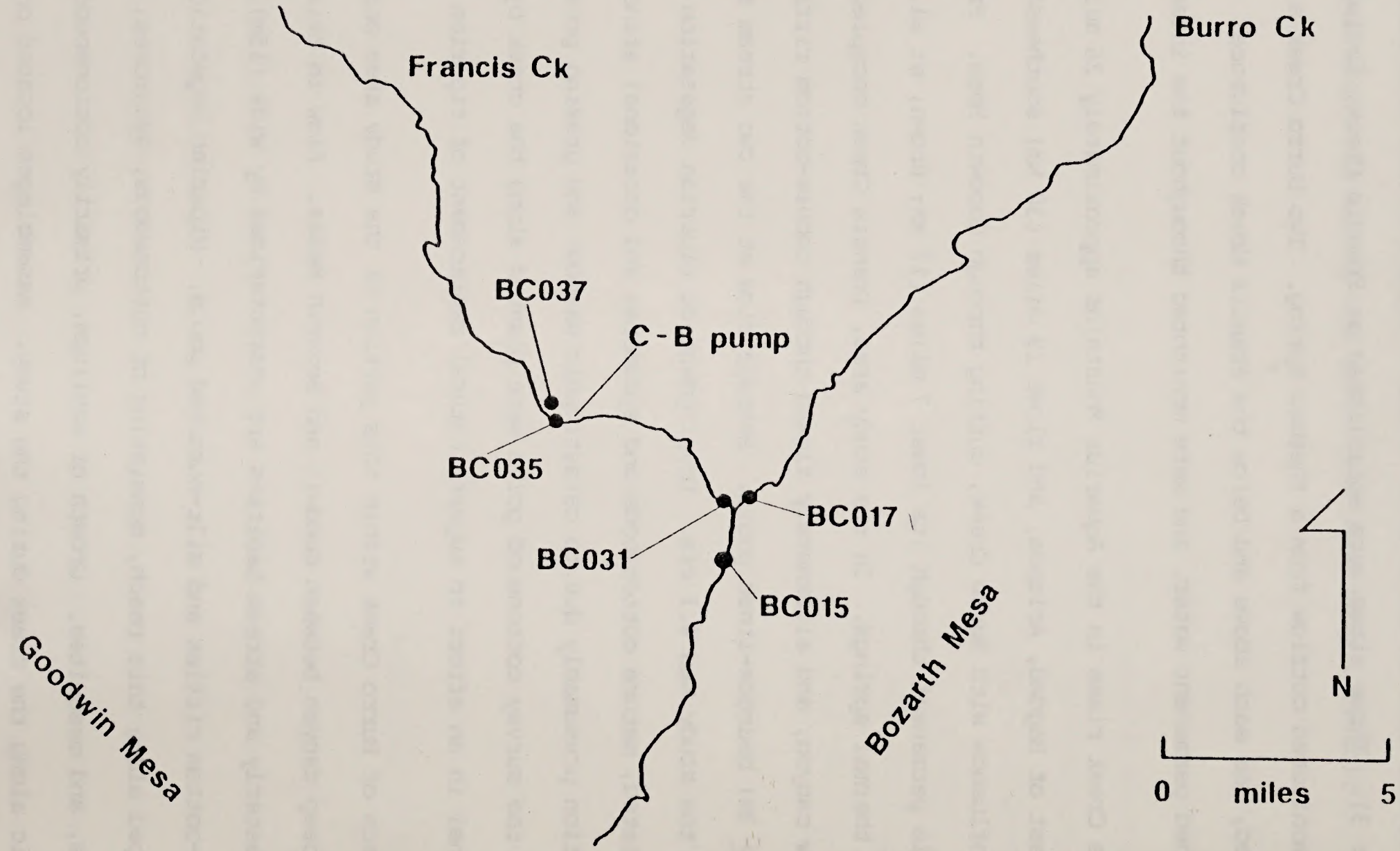
FRANCIS CREEK AND UPPER BURRO CREEK

A. Description: This portion of the study area includes five sampling sites (Figure 3). Three sites were established on Francis Creek, including one which monitored outflow from a thermal spring. Two Burro Creek sites were selected, one each above and below the Francis Creek confluence. All sites contained permanent water, and were monitored throughout the intensive survey.

Francis Creek rises in the Aquarius Mountains approximately 26 miles (42 km) northwest of Bagdad, Arizona, and flows 19 miles (30 km) southeasterly to its confluence with Burro Creek, cutting through Goodwin Mesa. Francis Creek is permanent through its lower 7 miles (12 km; Brown, et al., 1978), fed by thermal springs. In the study area, Francis Creek occupied a narrow, shallow canyon, and alternately flowed through cobble-bottom riffles and deep ($\geq$ 3m) bedrock-lined pools. Average flow at the two stream sites sampled during the study was 4.1 cfs. Development of riparian vegetation was limited to isolated, mature cottonwoods and sycamores and occasional stands of seepwillow, limitation presumably due to catastrophic washout and grazing pressure. During the survey cottonwood poles were planted along the creek by USBLM personnel in an effort to augment natural replacement of riparian galleries.

The reach of Burro Creek within this portion of the study area occupies a wide, deep canyon between Goodwin and Bozarth Mesas. Flow in this reach is southwesterly and stream habitats are characterized by wide (15m), shallow, cobble-bottom riffles and silt-bottomed pools. Riparian vegetation was well-developed along this reach, consisting of cottonwoods, sycamores, Goodding's willows, and mesquites. Growth of saplings, primarily cottonwoods, was prolific along the creek during the study. Assemblages located on streamside benches were often underlain by Bermuda grass (Cynodon dactylon) or other,

Figure 3.
Francis Creek and
upper Burro Creek



taller grasses. Instream vegetation was dominated by dense epilithic algal communities. A diverse native fish fauna was present in both Burro and Francis Creeks, including five native species (speckled and longfin dace, Sonora and desert suckers, and roundtail chubs) and introduced green sunfish. Deep pools in Francis Creek apparently provided optimal habitat for suckers and chubs as many large (>6 inch) individuals of each were seen during the survey. Two bald eagle sitings were made by field personnel during the survey, one on Francis Creek near site BC035 in February, 1982, and one on Burro Creek at site BC015 in February, 1983.

This portion of the study area is remote and virtually undeveloped. A pump station on Francis Creek near site BC035 is operated by Cyprus-Bagdad to supply domestic water for its operations. The station draws upon the thermal aquifer, and along with grazing constitutes the major cultural influence in this area. Both of these factors and their effects on Francis and Burro Creeks will be discussed in the ensuing narrative.

B. Thermal Springs on Francis Creek: Much of the base flow in Francis Creek appeared to originate from a series of thermal springs, located approximately 10 km upstream from the creek's confluence with Burro Creek. The springs emanated from a series of lateral fissures in the exposed bedrock; this flow was augmented by artesian water from a series of drill holes placed in the area by Cyprus-Bagdad. A single spring (site BC037) was sampled throughout the background and intensive survey. This, and other springs, seeps, and drill holes in the area contained permanent flow. The temperatures and specific conductance values for these various sources were spot-checked at various times, and were similar to values obtained for BC037, indicating that their flows orginated from a single subterranean source. The spring at

BC037 manifested constant discharge throughout the study period, discharge which was estimated at 0.25 cfs.

The physicochemical characteristics of BC037 are given in Table 5. Most of these characteristics remained stable throughout the study. Water temperatures ranged from 27 to 32°C, and were in winter considerably elevated over ambient stream temperatures (Figure 4). Water temperatures at the site declined slightly but steadily during the study. The reason for this decline, whether due to anthropogenic alteration of the underlying aquifer via drilling or a natural recharge cycle is unknown.

Spring water was slightly alkaline, although pH values were usually slightly depressed in comparison with area streams. The pH ranged from 7.3 to 7.7 standard units, with lower values tending to occur during the latter portion of the study. Dissolved oxygen values were likewise stable, ranging from 6.6 to 7.4 mg/l. The water was consistently undersaturated with regard to dissolved oxygen, but tensions were always sufficiently high to maintain an oxidizing environment in spring waters, as witnessed by the lack of hydrogen sulfide odor at the springs, the presence of high nitrate levels, and the virtual absence of dissolved or suspended metals. The waters of the springs were virtually free of suspended solids. Amounts of non-filterable residue were with a single exception less than 1 mg/l throughout the study.

Water at BC037 was dominated chemically by calcium, which constituted 52% of cations by weight, and bicarbonate, which accounted for 78% of the aqueous anions by weight. Sodium and magnesium were present in approximately equal proportions, and spring waters were notable in that they contained potassium concentrations ($\sim$ 6 mg/l) that were among the highest observed during the survey. Chloride and sulfate concentrations were far below recommended drinking

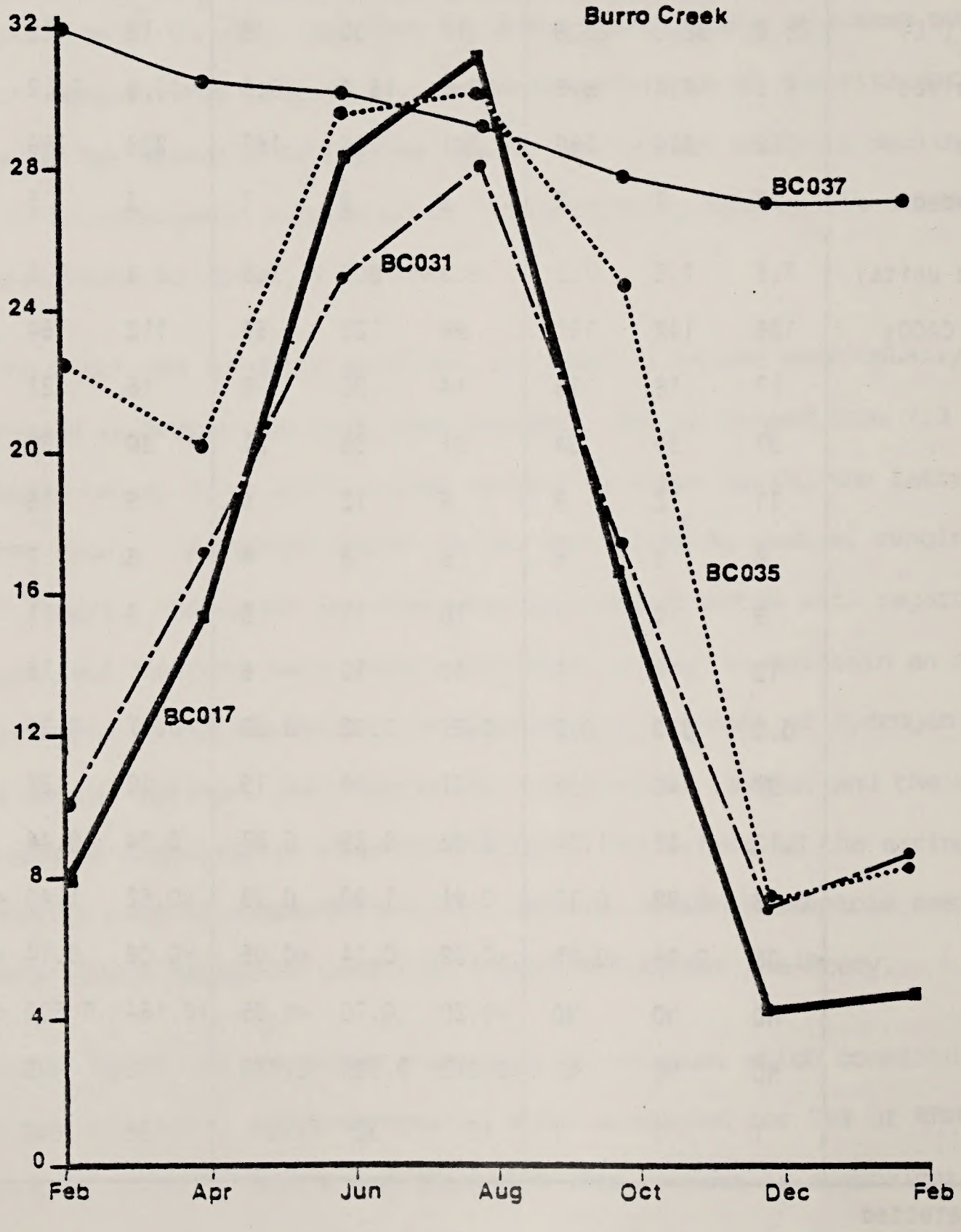
Table 5. Physicochemistry of intensive survey sites in the Francis Creek drainage. All quantities mg/l except where indicated.

Parameter	Site* BC037 mean	BC037 max.	BC037 min.	BC035 mean	BC035 max.	BC035 min.	BC031 mean	BC031 max.	BC031 min.
Temperature (^oC)	28.8	32.0	26.8	17	30	5	16	28	7
Oxygen, dissolved	6.9	7.4	6.6	10.5	13.4	9.6	10.8	13.2	9.2
TDS, residue	262	314	189	241	306	167	228	289	273
Total suspended solids	7	7	7	3	5	1	3	5	1
pH (standard units)	7.5	7.8	7.2	8.3	8.9	7.8	8.3	8.6	7.7
Alkalinity, $CACO_3$	125	142	111	98	128	55	112	154	67
Na	17	18	16	14	20	8	16	21	10
Ca	37	39	34	31	38	21	30	39	24
Mg	11	12	9	9	12	6	9	13	6
K	6	6	6	6	6	4	6	7	4
SO_4	9	10	7	10	11	8	9	11	6
Cl	12	14	11	10	13	5	11	15	5
F	0.3	0.3	0.2	0.25	0.32	0.20	0.37	0.34	0.22
Si	37	40	36	31	39	19	30	37	23
NO_3-N	1.13	1.25	1.04	0.62	0.89	0.27	0.24	0.44	0.03
Kjeldahl-N	0.48	0.88	0.11	0.91	1.80	0.33	<0.62	1.40	<0.20
Total PO_4-P	<0.05	0.06	<0.05	<0.09	0.14	<0.05	<0.06	0.14	<0.05
Fe, total	ND	ND	ND	<0.20	0.70	<0.05	<0.164	0.500	<0.05
Mo, total	ND	ND	ND	<0.012	0.020	<0.010	ND	ND	ND
Fecal coliforms (cfu/100 ml)	1	1	1	11	32	< 2	55	540	< 3

ND - not detected

* sample size for each site = 7

Figure 4.
H_2O temperature,°C
Francis Creek,
Burro Creek



water limits and suggested freshwater life criteria (USPHS, 1962; McKirdy, 1965; NRC, 1977). Notable in their virtual absence from spring waters were fluoride and manganese, which are common constituents of thermal groundwaters (Feth and Hem, 1963; Minckley and Sommerfeld, 1979). Silica concentrations were high in the spring compared with non-thermal waters, and reached 40.3 mg/l as Si in December. The chemistry of silica in natural water is complex and not fully understood (Edwards and Liss, 1973), but silica concentrations are highly temperature dependent, and the thermal nature of the springs was likely responsible for their high silica content.

As mentioned, heavy metals were virtually absent in spring waters. Total copper was the only metal present at levels exceeding laboratory detection limits. Copper was detected only once, when 0.020 mg/l of the metal appeared in October. The lack of metals bespeaks not only oxidizing environment of spring water, which would serve to place strict limits on the solubilities of many metals, but also the lack of significant mineralization in the underlying aquifer, as generally soluble species such as molybdate were also absent.

Waters at BC037 were consistently enriched in nitrogen and phosphorus, derived presumably from dissolution of underlying rock strata. Nitrate nitrogen concentrations reached 1.25 mg/l in April, and were continually in excess of 1.0 mg/l. This nitrate is almost certainly of natural origins since the watershed lacks cultural sources for the ion, such as intensive agriculture. Nitrate nitrogen in these springs may result from subterranean evaporite deposits (Brown and Caldwell, 1979). Kjeldahl nitrogen was also present at concentrations as high as 0.88 mg/l. Most of this trivalent nitrogen probably occurred as inorganic ammonium (NH_4^+) since there was little opportunity for biological transformation of nitrogen in spring waters at the point of collection. Similar levels of

ammonia nitrogen have been documented in other thermal waters in Arizona (Rampe, et al., 1981; Jackson, 1980).

The levels of nitrate nitrogen in the spring were well below 10 mg/l, a level which would compromise these waters' suitability as a domestic supply (USPHS, 1962). Still, total nitrogen content of the water averaged 1.71 mg/l, and was presumably present in forms readily available for use as plant nutrients. The springs therefore represent a significant source of nitrogen nutrients for downstream aquatic communities in Francis and Burro Creeks. Assuming flow at BC037 to be 0.25 cfs, water emanating from this single fissure would contribute 1.07 kilograms of readily usable nitrogen per day to the downstream ecosystem. Assuming that most of the base flow in Francis Creek during dry periods emanates from springs with chemistries similar to BC037, as seems likely given the chemical characteristics of Francis Creek, the total contribution of nitrogen from surfacing groundwater in the area would be 6.32 kilograms per day or 2,306 kilograms per year. This is a very large nitrogen flux for such a small ecosystem, and would probably result in severe eutrophication were the waters of Francis Creek to be impounded (Vollenweider, 1970).

Phosphorus was present consistently in spring water, albeit at levels close to laboratory detection limits (0.05 mg/l for total P; 0.03 mg/l for ortho P). Most of the detected phosphorus was ortho (or dissolved) phosphorus, which is a form easily assimilated by plants. The average ratio of total nitrogen to total phosphorus in spring water was approximately 43, indicating the probable evolution of phosphorus limitation in downstream communities, assuming that spring water was the major source of phosphorus for downstream producers. Phosphorus nonetheless appeared in the springs on a more consistent basis than at any other site sampled during the intensive survey, and the

springs represented one of the few sources for this rare nutrient during low base flow periods in the Burro Creek watershed.

A single sample of spring water was analyzed in October for the presence of fecal coliform bacteria. As expected, the sample was practically devoid of fecal coliforms, containing one colony forming unit per 100 ml.

C. Francis Creek Proper: Two sites were sampled on Francis Creek. Site BC035 was located approximately two hundred yards downstream of the spring outflow at BC037, and approximately the same distance upstream of the Cyprus-Bagdad pump station. Site BC031 was located approximately fifty yards upstream from Francis Creek's confluence with Burro Creek. Both sites were located in riffles.

Permanent water was present at both sites, and throughout the creek during the survey. Sampling was initiated during the relatively dry winter of 1981-82, and ended during the wet winter of 1982-83 (Figure 2). Discharge in the creek reflected this weather pattern. Stable base flow during dry months was maintained by the thermal springs; this condition was present from February through October, 1982. The minimum flow encountered during this period was 0.96 cfs at BC031 in June. Seasonal rains were responsible for increases in streamflow in December, 1982 and February, 1983 (Figure 5). A maximum discharge of 14 cfs occurred at BC031 in February, 1983, which at that time was sampled several days after heavy winter rains in the watershed.

Discharge at the mouth of Francis Creek was higher than at the upstream site on all but one occasion, in June (flow was monitored at only one site in February, 1982). The difference in flow proved not to be significant statistically when a t-test was performed on the data (alpha=0.05; Zar, 1974), but occurred consistently enough to suggest that Francis Creek between sites

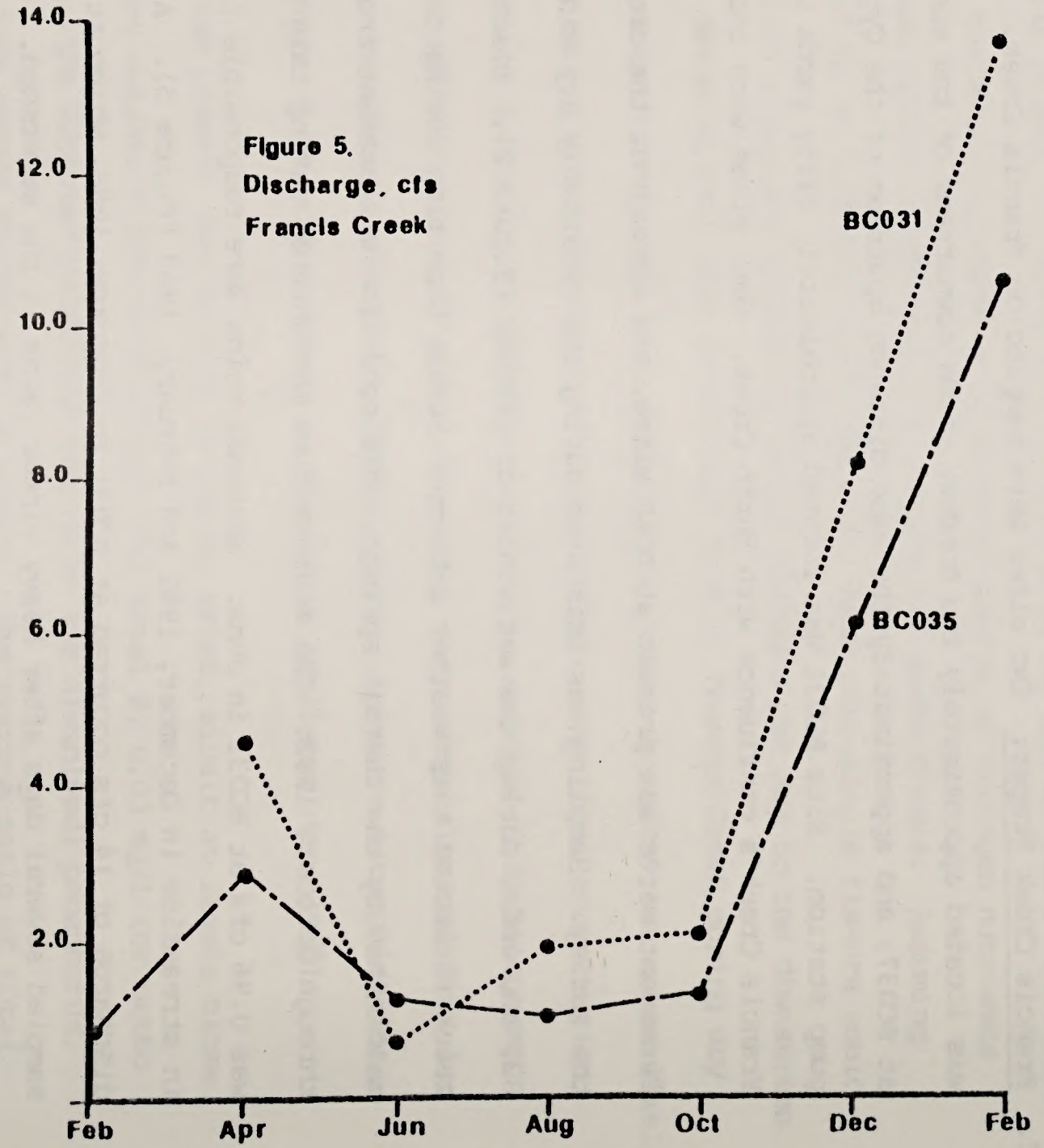


Figure 5.
Discharge, cfs
Francis Creek

BC035 and BC031 is a gaining segment. Disparities between flows at the two sites were highest during periods of highest discharge, indicating the presence of ephemeral water sources, such as, perhaps, Spencer Creek, that contributed flow to the creek in response to precipitation.

Questions exist as to the effects of pumpage by Cyprus-Bagdad on the hydrology of Francis Creek, and on the creek's ability to maintain the minimum flow necessary for support of instream communities in the face of continued pumping (Turner and Tafanelli, 1983). The observed increase in streamflow between sites BC035 and BC031 took place despite pumping by Cyprus-Bagdad, which occurred continuously through the survey except during February, 1983. The source of water for pumpage was a diverted surface spring which was pumped at on approximate rate of 1000 gallons per minute (2.23 cfs), a rate which often equalled or exceeded downstream flow in Francis Creek (P.K. Medhi, Cyprus-Bagdad Corp., pers. comm.). Field personnel noted considerable discharge emanating from a pipe located beneath the pump station in February, 1983 when the pump was not operating; much of this discharge otherwise would have been diverted for use by Cyprus-Bagdad. Water levels in Francis Creek were high at this period, however, and the discharge made up only a small portion of downstream flow.

Concern regarding the effects of Cyprus-Bagdad's pumping operation and apparent attempts to augment stream flow by drilling should be expressed in light of the uses that this water currently finds, and future management actions contemplated for the drainage. Waters of Francis Creek and its associated springs are of excellent chemical quality and well-suited for domestic use. They likewise are of superior quality for the support of aquatic life and wildlife. Francis Creek, and to a great extent Burro Creek, are dependent

upon the thermal springs for flow maintenance. Flow observed during the intensive survey appeared to be adequate to sustain the riparian communities of Francis and Burro Creeks, but at times may have been barely above the minimum amount of water required to do so. To ensure that adequate flow is maintained in Francis Creek during dry seasons, USBLM and Cyprus-Bagdad should formally negotiate an agreement, possibly under the auspices of the Arizona Department of Water Resources, whereby water withdrawals by Cyprus-Bagdad may be limited to current levels. Discussions should be initiated to explore the possibility of flow augementation of Francis Creek via reduced pumping by Cyprus-Bagdad during periods of extreme drought. A clear, formal understanding of the nature of consumptive water use by Cyprus-Bagdad, its effects on downstream flow, and water use options during times of low flow should be arrived at by USBLM as part of the implementation of the Burro Creek Riparian Management Area Plan (USBLM, 1983), and prior to the engagement of management options such as Arizona's Unique Waters designation (AWQCC, 1981).

The physicochemistry of Francis Creek was determined by the characteristics of its source springs, biological activity, and, following periods of significant precipitation, the chemistry of runoff water (Table 5). Water temperatures at site BC035 were elevated over ambient conditions during the winter of 1981-82 due to the influence of the thermal springs (Figure 4). This temperature stability was broken during December and February, 1982-83, when runoff from winter rains reduced instream temperature. Water temperatures in Francis Creek did not reach the low levels found in Burro Creek at this time, however, indicating that the thermal springs were effective in ameliorating water temperature somewhat even during high flows. The temperature elevation of Francis Creek waters was not as apparent at site BC031, 7 km downstream from the springs, which had an annual temperature regime similar to that of

the Burro Creek site located upstream of Francis Creek.

Concern has been expressed regarding potential adverse effects of the thermal loadings from Francis Creek springs on the reproductive cycles of native fishes, which may require periods of cool water temperatures for gamete maturation (Turner and Tafanelli, 1983). No data were gathered in this study to evaluate this hypothesis. However, Francis Creek in the vicinity of the thermal springs supported a dense periphyton community at all seasons as well as an abundant and diverse fish fauna, comprising five native species and the introduced green sunfish. Differences in the periphyton community between the two Francis Creek sites were noted in February, 1982. BC035 supported a benthic array dominated (apparently) by a mat composed of blue-green filamentous algae and diatoms. The community at BC031 at that time was sparser, characterized by patches of green algae and epilithic diatoms.

Francis Creek's productivity was reflected in its physicochemical characteristics. The pH at both Francis Creek sites was consistently alkaline; values usually ranged from 8.1 to 8.6 standard units. These values, higher than those found in the thermal springs, were likely due to instream photosynthesis, which consumes free carbon dioxide and bicarbonate, causing a rise in free carbonate ion and thereby increasing pH (Cole, 1975). Lower values, below 8.0 standard units, were recorded in association with high flows in December and February, 1982-83 and were due to dilution by runoff. A reduction in instream primary productivity resulting from scouring and increases in turbidity may also have contributed to the pH decline. Dissolved oxygen saturations were usually above 100% at the two sites, and concentrations were uniformly above the State water quality standard for warm-water fisheries of 6.0 mg/l. Dissolved oxygen saturations were higher at BC035 than at BC031 throughout

most of the survey, indicating the former site's particularly high productivity, fostered by the influx of warm, nutrient-laden spring water. Dissolved oxygen per cent saturation was low at both Francis Creek sites during the high flows of December and February, 1982-83, paralleling the trend observed for pH. Concentrations of oxygen in stream water remained high during this period, however, averaging about 11 mg/l.

Concentrations of major ions in Francis Creek during low flow were almost identical to those found in the thermal springs, indicating the creek's complete dependence on the springs for flow maintenance (Table 5). No upstream-downstream differences in ion levels were observed. Dilution by winter runoff in December and February, 1982-83 decreased total dissolved solids in Francis Creek by about 25%. The yearly fluctuation in major ions was small, however, when compared with other sites in the Burro Creek watershed (see Figure 29, page 127).

Heavy metal concentrations were uniformly low at both Francis Creek sites, as they were in the thermal springs. Levels of most metals did not reach laboratory detection limits during the course of the study. Iron was found in both total and dissolved form during the high discharge periods of December and February, 1982-83. Total iron concentrations reached 0.7 mg/l. Most of this iron was present in association with suspended sediments, which were present in somewhat higher concentrations at this time. Sediment-bound transport is an important mechanism for metal translocation in most unpolluted streams (Gibbs, 1973). The influx of metals from the surrounding watershed may be of particular importance to Francis Creek's metabolism, as productivity in this nitrogen-rich stream may at times be limited by the availability of iron and other nutritive metals.

Molybdenum was the only heavy metal found in the waters of Francis Creek during low flows. Total and dissolved molybdenum were found occasionally at both sites at levels near the laboratory detection limit of 0.01 mg/l. Molybdenum enrichment of Francis Creek water was probably the result of sediment dissolution, since measurable levels of this metal were not found in thermal spring water.

Nutrient levels in Francis Creek, particularly total nitrogen levels, were elevated in comparison with other waters in the drainage as a result of high concentrations in the springs. Geologically derived nitrate and ammonia are important constituents of the nitrogen budgets of other Arizona desert streams (Grimm, et al., 1981). Francis Creek is remarkable, however, in the large amount of nitrogen that it receives from this source (see discussion, page 30). Nitrate nitrogen concentrations were high throughout the survey at site BC035, although levels in the creek were lower than those in the thermal springs, presumably due to biotic uptake. Nitrate nitrogen concentrations ranged from 0.27 mg/l to 0.89 mg/l at this site. This variation was closely linked to variations in discharge, suggesting that dilution from runoff was an important factor in regulating nitrogen concentrations at site BC035. Nitrate concentrations at BC031 were lower than those at BC035 during most of the survey due to biological transformations of nitrate along the length of the creek. Such transformations include incorporation by primary producers and, in anoxic sediment microzones, denitrification and subsequent volatilization of nitrous oxide and molecular nitrogen (Wetzel, 1975). Nitrate nitrogen concentrations at site BC031 varied from 0.02 mg/l to 0.44 mg/l.

Variation in nitrate nitrogen levels at the lower Francis Creek site exhibited different pattern than that observed in the vicinity of the thermal springs.

Rather than being a response to stream discharge, nitrate nitrogen variation at BC031 was strongly seasonal, with minimum values occurring during the summer (Figure 6). Low nitrate values at this site corresponded with high dissolved oxygen saturations (an indication of high primary productivity), thus suggesting that seasonal variation in periphyton growth was of prime importance in regulating nitrate nitrogen at the downstream site in Francis Creek.

Kjeldahl nitrogen concentrations at both Francis Creek sites were low during winter and spring of 1982, but increased with the onset of summer, indicating the biological transformation of inorganic nitrate and its subsequent release as organic trivalent nitrogen. Elevated levels of Kjeldahl nitrogen in stream waters during the winter of 1982-83 were probably the result of precipitation runoff, which transports large quantities of nitrogen to desert streams from surrounding watersheds (Fisher and Minckley, 1978).

Both sites on Francis Creek contained measurable levels of either ortho (dissolved) or total phosphate phosphorus during most of the intensive survey. Values ranged from 0.01 mg/l ortho phosphate phosphorus, found at BC031 in October, to 0.14 mg/l total phosphate phosphorus, found at both sites during December and February, 1982-83. Although data for phosphorus are somewhat incomplete, seasonal patterns appeared to emulate those of nitrate nitrogen at BC035 in that the low values occurred during the summer growth period and high values occured during winter runoff.

A single high fecal coliform count of 540 cfu/100 ml was noted at BC031 in October, which was probably the result of undetected animal droppings in the vicinity of the sample collection site. This value approached but did not exceed the State's single sample allowable maximum of 800 cfu/100 ml for waters protected for full body contact recreation. The State standard for

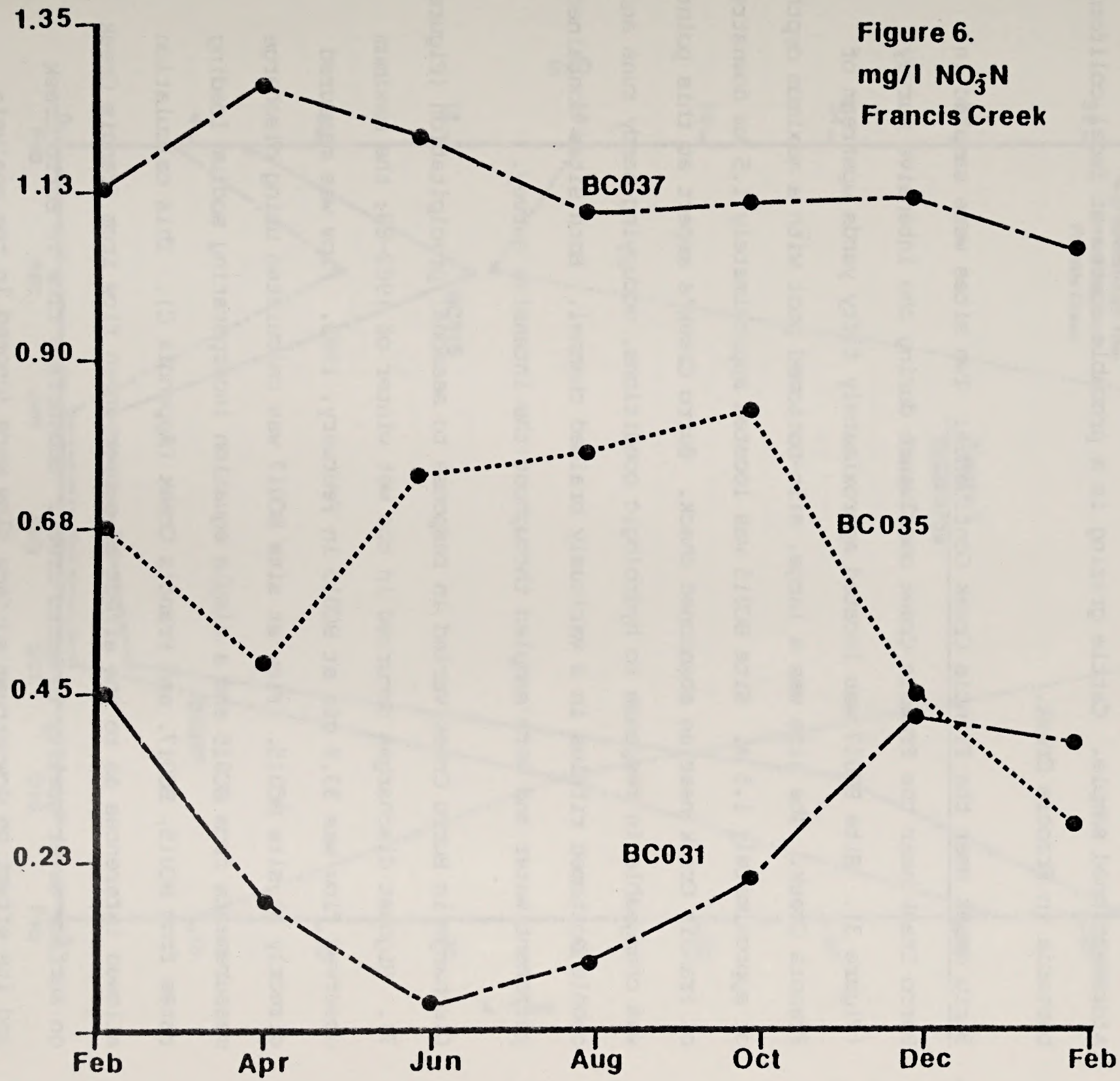


Figure 6.
mg/l NO_3^-N
Francis Creek

beneficial uses that apply to Francis Creek (i.e., partial body contact, aquatic and wildlife protection, and livestock watering) is 4000 cfu/100 ml for a single sample. Most samples collected from Francis Creek contained measurable fecal coliform populations, albeit at levels much lower than the aforementioned sample. Cattle grazing is a probable source of fecal coliform bacteria in Francis Creek.

D. Burro Creek Near the Francis Creek Confluence: Two sites were sampled in Burro Creek near the Francis Creek confluence during the intensive survey (Figure 3). Site BC017 was located approximately fifty yards upstream of Francis Creek. The site was a large, silt-bottomed pool with a maximum depth of approximately 1.5 m. Site BC015 was located approximately 1.5 km downstream of Francis Creek near an abandoned shack. Burro Creek's aspect at this point was changeable in response to hydrologic conditions, occupying sandy runs and cobble-bottomed riffles in a variously braided channel. Both sites contained permanent water and were sampled throughout the intensive survey.

Discharge in Burro Creek varied in response to seasonal precipitation (Figure 7). Highest discharges occurred in the wet winter of 1982-83; the maximum observed flow was 33.8 cfs at BC015 in February, 1983. Flow was measured directly at site BC015. Flow at site BC017 was calculated using discharge measurements from BC015 and a simple equation incorporating sodium loading rates from BC015, BC017, and Francis Creek (Appendix C). This calculation allowed inferences as to the effect of subterranean flow from Francis Creek on surface water quality in Burro Creek. Subsurface flow in Burro Creek and its effect on downstream surface flow were ignored in the analysis, introducing a degree of systematic error into the approximation whereby surface discharge at BC017 was perhaps overestimated. Burro Creek at site

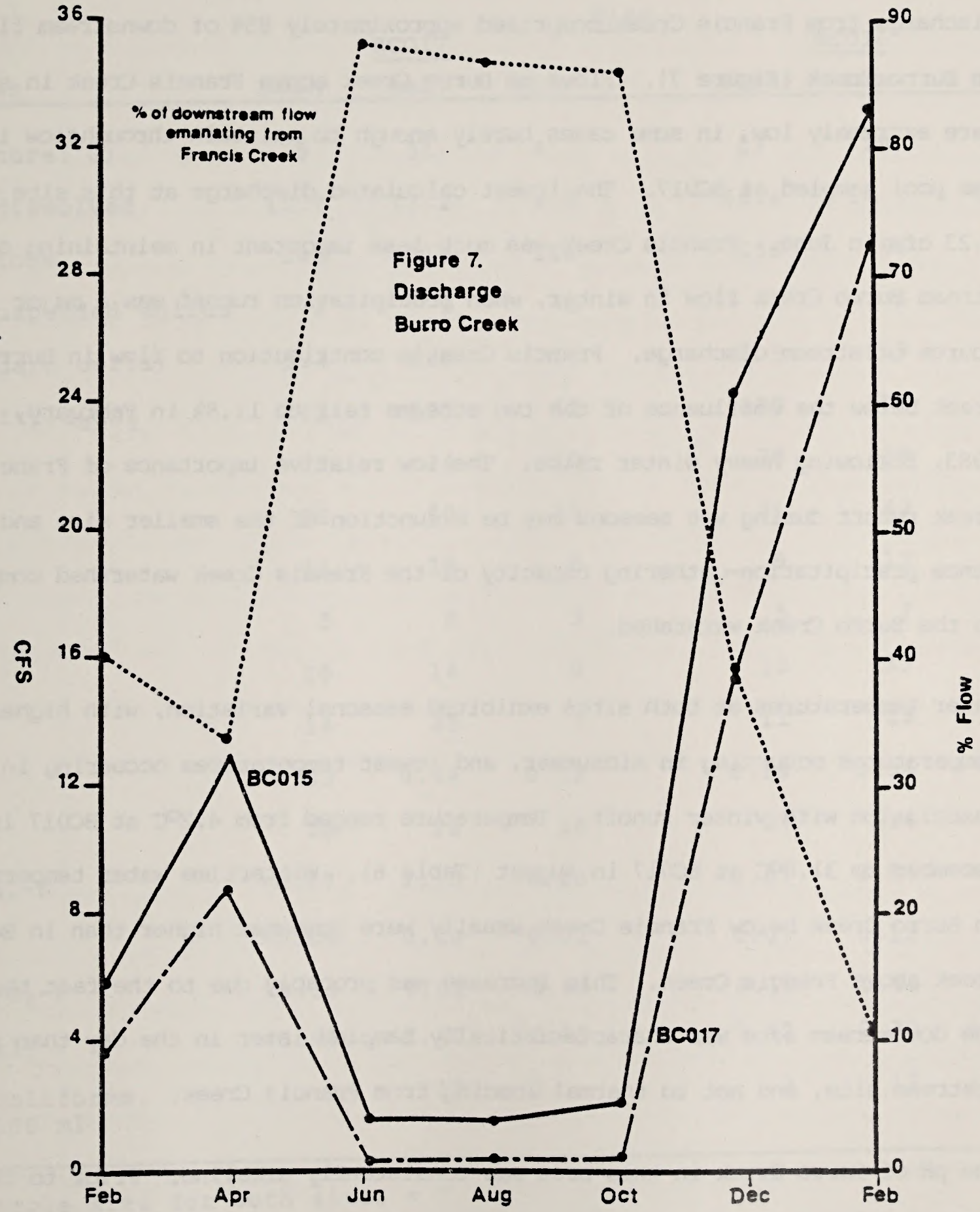


Figure 7.
Discharge
Burro Creek

BC015 was heavily dependent on Francis Creek for flow maintenance during dry periods. During June, August, and October, when flows were lowest, discharge from Francis Creek comprised approximately 85% of downstream flow in Burro Creek (Figure 7). Flows in Burro Creek above Francis Creek in summer were extremely low, in some cases barely enough to maintain throughflow in the pool sampled at BC017. The lowest calculated discharge at this site was 0.23 cfs in June. Francis Creek was much less important in maintaining downstream Burro Creek flow in winter, when precipitation runoff was a major source of stream discharge. Francis Creek's contribution to flow in Burro Creek below the confluence of the two streams fell to 11.8% in February, 1983, following heavy winter rains. The low relative importance of Francis Creek runoff during wet seasons may be a function of the smaller size and hence precipitation-gathering capacity of the Francis Creek watershed compared to the Burro Creek watershed.

Water temperatures at both sites exhibited seasonal variation, with highest temperatures occurring in midsummer, and lowest temperatures occurring in association with winter runoff. Temperature ranged from 4.2°C at BC017 in December to 31.0°C at BC017 in August (Table 6). Wintertime water temperatures in Burro Creek below Francis Creek usually were somewhat higher than in Burro Creek above Francis Creek. This increase was probably due to the fact that the downstream site was characteristically sampled later in the day than the upstream site, and not to thermal loading from Francis Creek.

The pH of Burro Creek in this area was consistently alkaline. Prior to the influx of precipitation runoff in December, the lowest pH observed at these two sites was 8.5 standard units. The pH at both sites decreased in December, 1982 and February, 1983 during a period of increased discharge in the creek.

Table 6. Physicochemistry of intensive survey sites in Burro Creek near Francis Creek. All quantities mg/l except where indicated.

	Site					
	BC017			BC015		
Parameter	mean	max.	min.	mean	max.	min.
Temperature (°C)	15	31	4	17	29	7
Oxygen, dissolved	11.7	13.2	9.5	12.4	14.4	10.6
TDS, residue	240	316	168	253	366	171
Total suspended solids	2	7	<1	<2	5	<1
pH (standard units)	8.4	8.8	7.7	8.5	8.9	7.8
Alkalinity, $CaCO_3$	141	190	62	120	176	66
Na	29	44	10	20	28	10
Ca	32	50	19	31	42	20
Mg	11	19	6	9	13	5
K	5	8	3	5	7	3
So_4	10	14	8	10	13	6
Cl	14	25	3	11	15	4
F	0.33	0.44	0.19	0.28	0.34	0.19
Si	20	25	16	25	34	17
Kjeldahl-N	<0.67	2.10	<0.20	<0.57	0.94	<0.20
NO_3-N	<0.04	0.10	<0.01	0.07	0.15	0.01
Total PO_4-P	<0.13	0.62	<0.03	<0.17	0.82	<0.03
Fe, total	<0.60	3.40	<0.05	0.42	2.20	<0.05
Fecal coliforms, cfu/100 ml	4	12	<3	3	12	<3

* sample size for both sites = 7

The lowest pH (7.7 standard units) occurred at BC017 in February, 1983, following a winter storm.

Dissolved oxygen saturations at both sites were usually greater than 100%, varying on a seasonal basis (Figure 8). Saturation was highest in summer, and reached 165% at BC017 in June. While these excess oxygen levels are high for streams in general, which tend to achieve equilibria with atmospheric oxygen via turbulence, they may be typical of small desert streams. An oxygen saturation of 280% was recorded during summer in Sycamore Creek (Yavapai County, Arizona), a permanent, low-altitude creek in central Arizona (Busch and Fisher, 1981), and saturations similar to those found in Burro Creek were recorded in tributaries of the Gila River in the southeastern portion of the state (Minckley and Sommerfeld, 1979). Dissolved oxygen saturations near or below 100% occurred in Burro Creek during the winter of 1982-83. Oxygen concentrations at both sites were high throughout the survey. The lowest dissolved oxygen concentration recorded from either site was 9.5 mg/l, well in excess of the State surface water quality standard for the protection of aquatic life of 6.0 mg/l.

The pH levels and dissolved oxygen saturations recorded in Burro Creek bespeak the highly productive nature of this system. Both pH and oxygen in aquatic habitats are largely determined by photosynthetic rates, which in Burro and Francis Creeks were controlled by the activity of periphytic algae, the most abundant primary producers. Although no direct productivity measurements were made during the survey, it appeared that Burro and Francis Creeks were autotrophic, at least during summer and/or periods of prolonged, stable base flow. Autotrophy is a state where instream photosynthesis exceeds respiration (witnessed in this case by oxygen saturations which substantially exceeded

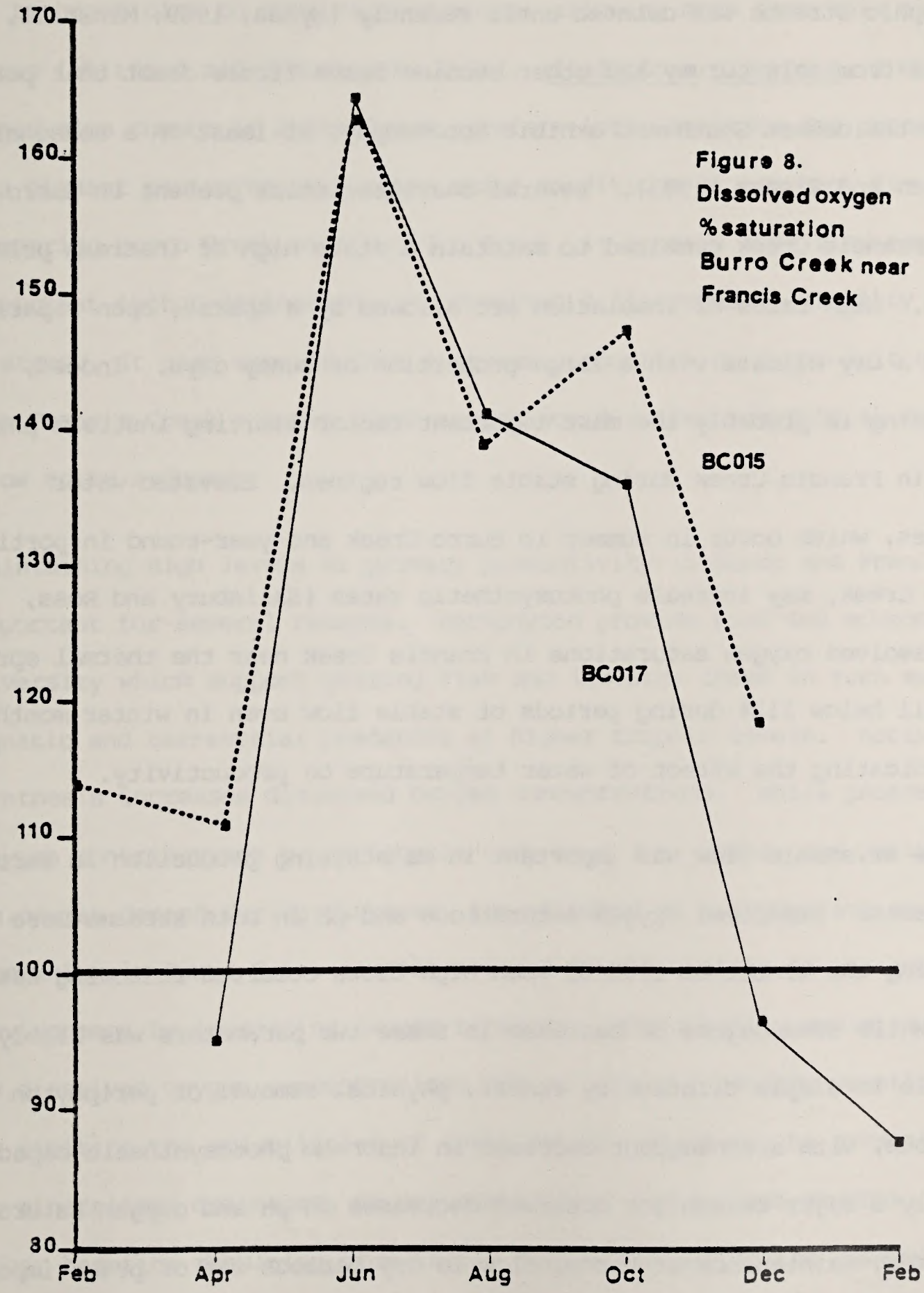


Figure 8.
Dissolved oxygen
% saturation
Burro Creek near
Francis Creek

100%), and carbon fixed by instream producers forms the most important energy base for maintenance of higher trophic levels in the community. The existence of autotrophic streams was debated until recently (Hynes, 1969; Minshall, 1978), but results from this survey and other studies leave little doubt that permanent streams in the desert Southwest exhibit autotrophy, at least on a seasonal basis (Busch and Fisher, 1981). Several characteristics present in Burro Creek and Francis Creek combined to maintain a state high of instream primary production. High rates of insolation are allowed by a sparse, open riparian canopy and a dry climate with a large proportion of sunny days. Indeed, canyon shading is probably the most important factor limiting instream photosynthesis in Francis Creek during stable flow regimes. Elevated water temperatures, which occur in summer in Burro Creek and year-round in portions of Francis Creek, may increase photosynthetic rates (Salisbury and Ross, 1969). Dissolved oxygen saturations in Francis Creek near the thermal springs did not fall below 112% during periods of stable flow even in winter months, perhaps indicating the effect of water temperature on productivity.

Maintenance of stable flow was important in maintaining production in Burro and Francis Creeks. Dissolved oxygen saturations and pH in both streams were lowest during the winter of 1982-83 when high flows occurred following wet weather. While some degree of decrease in these two parameters was likely attributable to simple dilution by runoff, physical removal of periphyton during floods, with a consequent decrease in instream photosynthetic capacity, was probably a major reason for observed decreases in pH and oxygen saturation. During summer, maintenance of throughflow in dry periods was of prime importance in sustaining periphyton activity. The high oxygen saturations observed in summer in Burro Creek were in sharp contrast to the oxygen deficits found in Boulder Creek during the same time (see discussion, page 64). A major

difference between the sites was the lack of flow in Boulder Creek, which in summer had retreated to a series of isolated pools. Current has been shown to be beneficial to some algal species, allowing more favorable mineral uptake rates (Whitford and Schumacher, 1964). Cladophora glomerata, a macroscopic green alga common in Burro Creek, prefers lotic habitats and probably exhibits its highest photosynthetic rates under conditions of constant flow. In comparing Burro Creek with Boulder Creek, it appears that flow regime is an important factor delineating the observed differences in vitality of the two systems. It also appears that instream production on a per-unit basis in the Francis Creek - Burro Creek system would suffer substantial decline were flow to be reduced.

Maintaining high levels of primary productivity in Burro and Francis Creeks is important for several reasons. Periphyton provide food and microhabitat diversity which support grazing fish and insects; these in turn support aquatic and terrestrial predators at higher trophic levels. Active photosynthesis increases dissolved oxygen concentrations. While photosynthetic oxygen contributions by periphyton vary on a diel basis, and periphyton create an oxygen demand during darkness, the presence of a productive periphyton community in Burro Creek doubtless improved the quality of the aquatic environment by increasing oxygen tensions. Biologically mediated increases in dissolved oxygen concentrations and pH have a secondary beneficial effect by limiting the solubilities of toxic metals, which may be present naturally in mineralized drainages, or may result from contaminant sources. These and other benefits resulting from highly productive periphyton communities in Burro and Francis Creek, and the probable dependence of these communities on a minimum degree of throughflow add to the importance of ensuring that flow is maintained in Burro and Francis Creeks.

Major ions in this reach of Burro Creek were similar at both sampling sites as regards concentrations and seasonal behavior, although subtle differences attributable to inflow from Francis Creek were evident (Table 6). Variations in total dissolved solids levels were greater at BC017 than at BC015, indicating an ameliorating effect on Burro Creek chemistry by the chemically stable discharge from Francis Creek's thermal springs (Figure 9). TDS levels were highly dependent on variation in streamflow as determined by simple linear regression following transformation of data to natural logarithms (Zar, 1975; Hem, 1970). For BC017 r= -0.86, and alpha= 0.01; for BC015 r= -0.85, and alpha= 0.01. Bicarbonate was the dominant anion at both sites, comprising 77% of total anions by weight at BC017, and 73% at BC015. Free carbonate ion, allowed to exist via photosynthetic elevation of stream pH and utilization of bicarbonate (Wetzel, 1975), was present at both sites on a consistent basis. Sulfate and chloride concentrations were uniformly low, and did not approach levels specified in water quality criteria for aquatic life, drinking water supplies, or livestock watering (McKirdy, 1968; USPHS, 1962; McKee and Wolf 1963). Fluoride concentrations were likewise below USPHS recommended drinking water limits.

Calcium and sodium were the most abundant cations in this reach of Burro Creek. Calcium was uniformly dominant at BC015, but exhibited a crossover pattern with sodium at BC017 (Figure 10). At the latter site, calcium was the most abundant ion at all times except during August and October, when sodium became most common. The reason for this crossover is unclear, but may be linked to sodium-rich spring inputs whose effects were apparent only during periods of low streamflow, or to precipitation of calcium carbonate. Waters at both sites contained appreciable concentrations of magnesium and potassium. The average ratio of monovalent to divalent cations (MD) at both

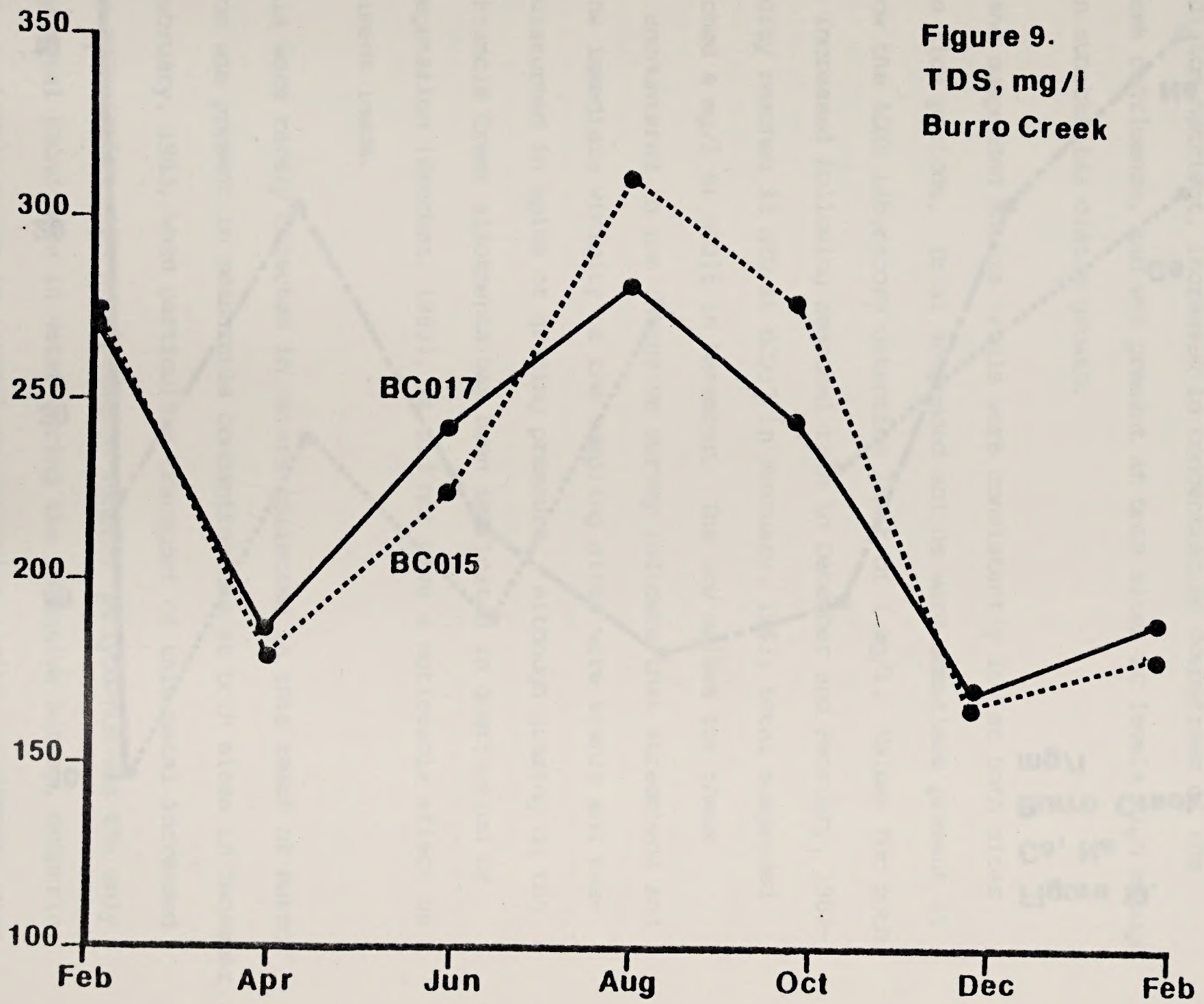
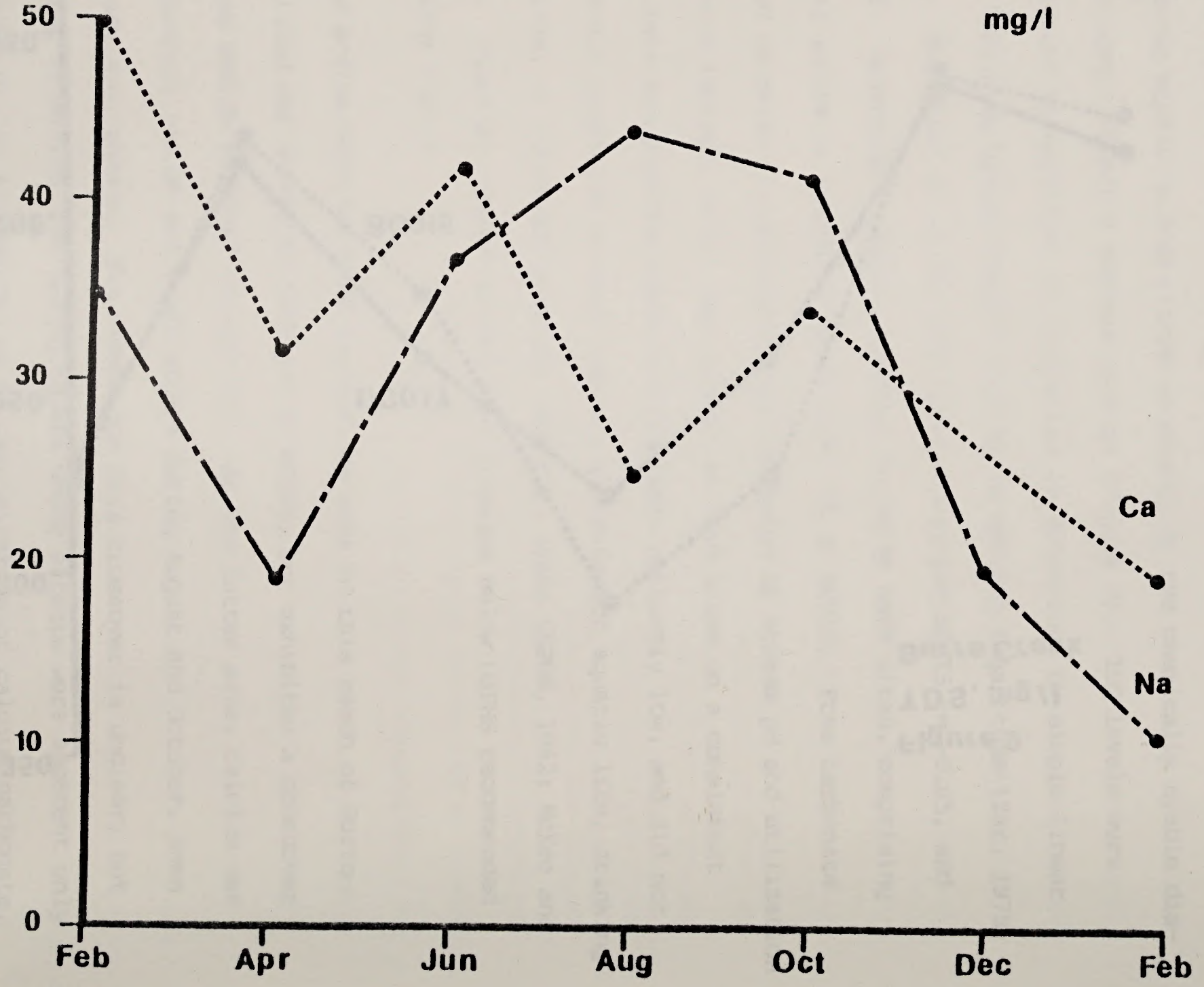


Figure 9.
TDS, mg/l
Burro Creek

Figure 10.
Ca, Na
Burro Creek, BC017
mg/l



sites was 0.8. The combination of abundant calcium, magnesium, and potassium and a low MD ratio (<4.5) indicated that Burro Creek, like Francis Creek, provides an excellent environment for growth of periphytic diatoms, and probably contributed to the creek's high productivity (Moss, 1975). Silica, another essential diatom nutrient, increased in concentration downstream of the Francis Creek confluence, and was present at both sites at levels high enough to maintain substantial diatom growth.

Turbidity and suspended solids levels were consistently low at both sites during base flow periods. Total suspended solids were sometimes present at levels below the ADHS laboratory detection limit of 1 mg/l. Values for both parameters increased following seasonal rain in December and February, 1982-83. Turbidity reached 33 NTU at BC017 in February, 1983; total suspended solids reached 4 mg/l at BC015 in December. The low values for these parameters encountered in the intensive survey indicate that streambeds and banks in the immediate vicinity of the sampling sites were stable and reasonably undisturbed in spite of grazing pressure. Although grazing on the Burro and Francis Creek allotments has been implicated in destruction of riparian vegetation (Sanchez, 1982), it did not have a noticeable effect on stream sediment loads.

Heavy metals were rarely detected in waters collected in this reach of Burro Creek. Iron was present in measurable concentrations at both sites in December, 1982 and February, 1983, when particulate transport of this metal increased in probable association with precipitation runoff. Molybdenum was the only other heavy metal found here in water during the intensive survey, occurring infrequently at levels close to laboratory detection limits. Sediments were collected at site BC015 and analyzed for heavy metals (Table 7). Concentrations

Table 7. Heavy metals and sulfate in Burro Creek sediments. All quantities mg/kg.

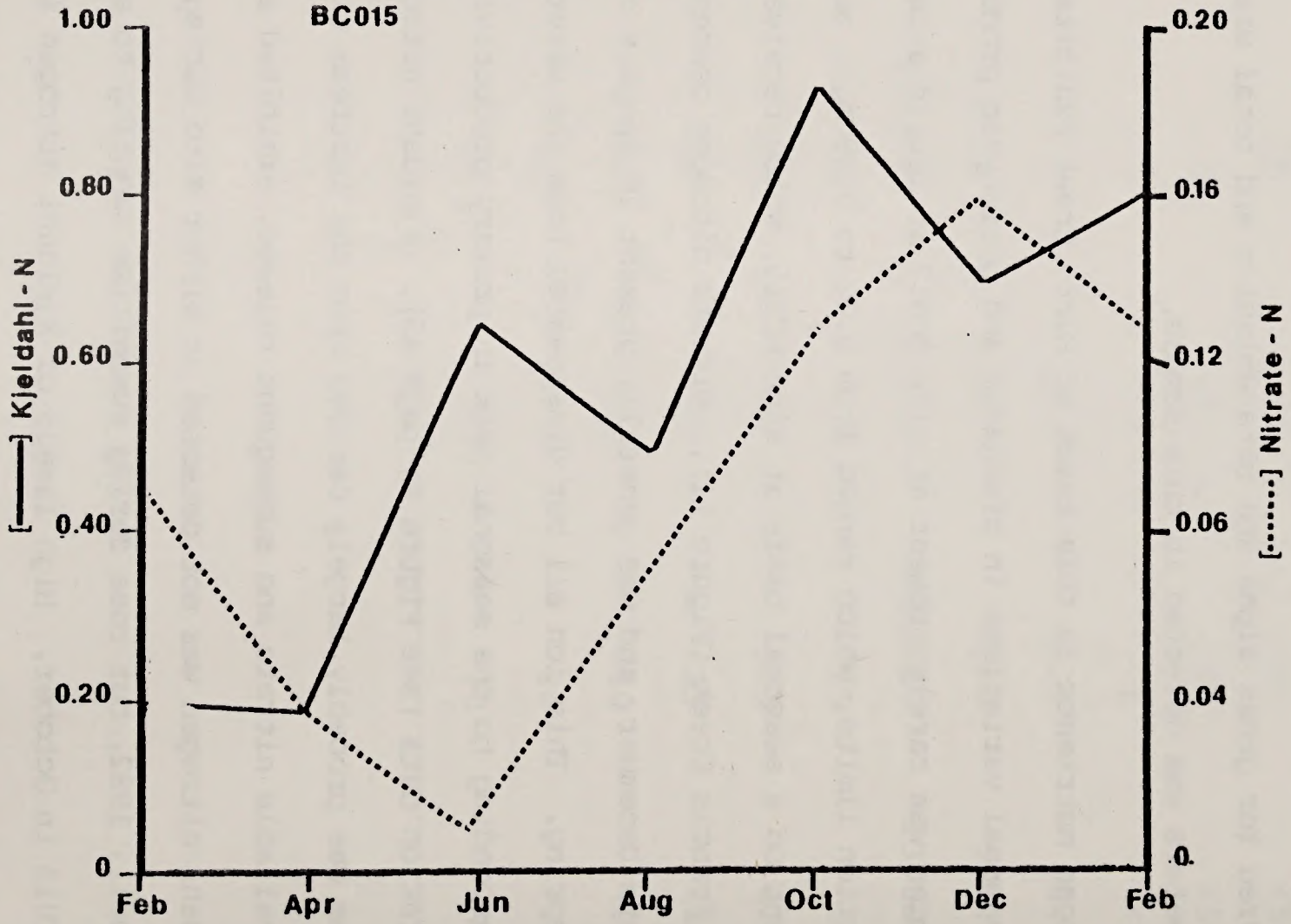
	Site					
	BCO15			BCO13		
Parameter	Oct.	Jan.	Feb.	Oct.	Jan.	Feb.
Antimony	<50	<50	<50	<50	<50	<50
Arsenic	<50	<50	<50	<50	<50	<50
Cadmium	1	< 1	<1	1	<1	<1
Chromium	54.8	7.1	10.2	45.5	20.4	9.9
Copper	40.0	30.9	20.9	60.0	305.0	39.0
Iron	24,000	10,495	11,750	23,000	13,095	15,640
Lead	70	<25	<25	<25	30	<25
Manganese	370	295	300	340	427	311
Molybdenum	<25	<25	<25	<25	<25	<25
Selenium	<25	<25	25	<50	<25	<25
Sulfate	84	27	8	24	11	13
Zinc	40	23	21	70	76	37

of metals were low in these sediments compared to those collected near contaminant sources in the Boulder Creek drainage, and were comparable in most cases to those concentrations of metals found normally in igneous rocks or sandstone (Hem, 1970).

A single water sample was collected in February, 1983 from site BC015 and analyzed for gross alpha and beta emission and total uranium. None of these parameters was detected in this sample.

Nitrogen nutrients in this reach of Burro Creek exhibited behavior traceable to seasonal variations in discharge and periphyton productivity. Nitrate nitrogen was rarely present at site BC017 at levels exceeding laboratory detection limits, which ranged from 0.02 to 0.09 mg/l as N. Nitrate was present on a seasonal basis at site BC015, which received nitrate-rich water from Francis Creek (Figure 11). Nitrate nitrogen concentrations reached 0.16 mg/l in December, and was generally present in samples collected in winter and spring. This ion all but disappeared from the water column in summer, corresponding to the seasonal peak in primary productivity observed in oxygen saturation data (see Figure 8, page 45). Kjeldahl nitrogen, which in this system was probably largely derived from the instream biological transformation of available nitrate and subsequent release, exhibited a different pattern. Kjeldahl nitrogen was not detected at either site during sampling in February or April, 1982, but rose during summertime sampling to as much as 0.94 mg/l at BC015 in October. High levels of Kjeldahl nitrogen (up to 2.1 mg/l) occurred at both sites in December and February, 1982-83, in association with the highest observed discharges at these sites. High discharge in desert watersheds often transports large amounts of Kjeldahl nitrogen and other nutrient species (Fisher and Minckley, 1978); in the case of Burro Creek and

Figure 11.
Nitrate and Kjeldahl Nitrogen, mg/l
BC015



other desert streams this transport may be attributed to influx of nutrients from poorly vegetated watersheds and the dislodging of the benthic stream community.

Total and dissolved phosphate phosphorus were seldom detected at these two Burro Creek sites during stable flow periods (February through October). Neither phosphorus parameter was present during this period in concentrations exceeding 0.05 mg/l as P. Measurable levels of total and dissolved phosphorus were present at both sites during the final two sampling periods, reaching 0.10 mg/l total P at BC015 in February, 1983. This paralleled the behavior of Kjeldahl nitrogen in the creek at this time, and was probably also due to high flow.

The primary factors controlling nutrient levels in Burro Creek during the intensive survey were biological activity, which influenced nitrate and Kjeldahl nitrogen concentrations on a seasonal basis, precipitation runnoff, which carried nutrients from the surrounding watershed and dislodged benthic material, and springs in Francis Creek, which caused a noticeable downstream increase in nitrate at site BC015. The effects of grazing on stream nutrient levels, if any, were not readily apparent. Levels of nutrients in Burro Creek were comparable to those found in other Arizona desert streams (e.g., Grimm, 1981; Minckley and Sommerfeld, 1979), but most streams in the State are also subject to grazing pressure. Ecological investigations on Aravaipa Creek, perhaps Arizona's most pristine desert creek, are not yet sufficient to fully enumerate instream nutrients levels there, but studies already performed suggest nutrient fluxes in the creek to be similar to those observed in Burro Creek (Minckley, 1980). Desert streams in general are productive environments that occupy sparsely vegetated watersheds of a type conducive

to high nutrient loss via precipitation runoff (Bormann and Likens, 1979). As a result, seasonally high and variable nutrient concentrations may be expected in such streams, whether or not moderate grazing pressure is present. Grazing can be expected to have effects on instream nutrient levels when it is heavy enough to cause bank destabilization and large-scale destruction of benthic communities. Such effects were not noted during the intensive survey. Damage from grazing appears thusfar to have occurred only to the terrestrial component of the Burro Creek riparian ecosystem; adverse effects on the quality of the aquatic environment were not discernible in this study.

Fecal coliform bacteria populations were low in this reach of Burro Creek. The highest observed value was 12 colony forming units per 100 ml, recorded at BC015 in June and BC017 in August. This level was far below State surface water quality standards for fecal coliform bacteria applicable to this stream.

E. Summary and Conclusions: The following conclusions may be drawn from the intensive survey regarding the water resources of Francis Creek and Burro Creek in this portion of the study area:

1. Thermal springs along Francis Creek are almost entirely responsible for maintenance of downstream flow in the stream and in Burro Creek during dry periods---Direct discharge measurements and water chemistry analyses confirmed the creek's dependence on the thermal springs for year-round flow maintenance. Cyprus-Bagdad removes an estimated 1,000 gpm continually from an impounded spring on Francis Creek, a significant amount in that it often exceeded total downstream surface flow in the creek. The amount of spring discharge allowed to enter the stream was apparently adequate to maintain flow in Francis and Burro Creeks throughout the study area during the intensive survey.

Water levels in both creeks became very low during summer, however, and discharge probably approached the minimum necessary to maintain throughflow in the creeks. Current rates of pumpage by Cyprus-Bagdad are probably compatible with maintenance of downstream aquatic habitats during most years, but reductions in pumpage would undoubtedly have a beneficial effect on these habitats during dry seasons. USBLM should negotiate a formal understanding regarding water withdrawals with Cyprus-Bagdad, one which reduces withdrawals as much as practical, quantifies those withdrawals, and makes allowances for streamflow maintenance during periods of extreme drought.

2. Thermal springs along Francis Creek are an important source of nitrogen and phosphorus for downstream primary producers---Total nitrogen in spring water averaged 1.7 mg/l, primarily in the form of readily usable nitrate and (presumably) ammonia. Phosphorus concentrations (approximately 0.05 mg/l as P) were high in comparison to other waters in the drainage, and were present consistently enough for the springs to be a significant source of this scarce nutrient. The result of these nutrient inputs, in combination with the thermal nature of the springs, was a lush periphyton community in Francis Creek in the vicinity of the springs and a diverse, abundant fish fauna.

3. A number of factors combine to make streams in this portion of the study area extremely productive aquatic habitats---Dissolved oxygen saturations in Burro and Francis Creeks exceeded 100% at all sites during most of the intensive survey, reaching 165% during the summer growth season. High year-round insolation rates, large amounts of

geologically derived nutrients, and favorable monovalent:divalent cation ratios contributed to the creek's productive nature. Maintenance of throughflow was judged to be important in sustaining periphyton growth when Burro and Francis Creeks were compared to less productive sites in intermittent reaches of Boulder Creek and Wilder Creek. The benefits of high primary productivity include a large fixed carbon base for the support of instream and terrestrial consumers, maintenance of high instream oxygen concentrations, and limitations on the solubilities of many toxic metals.

4. In general, grazing pressure did not have a demonstrable adverse effect on water quality in this portion of the study area---In some streams, overgrazing has been shown to have adverse effects on stream quality in terms of elevated levels of bacteria, suspended sediments, and nutrients, and a reduction in grazing has been proposed to mitigate these effects in Burro and Francis Creeks (USBLM, 1981). However, with the exception of one sample taken from Francis Creek which contained a high fecal coliform count (540 cfu/100 ml), these effects were not observed during the intensive survey. Suspended sediment levels were uniformly low (in some cases less than 1 mg/l) in these streams during stable flow periods, increasing slightly with increasing discharge. Nutrient levels were comparable to those obtained for other desert streams, and appeared to be regulated by natural spring sources, biological activity, and precipitation runoff. Reduction in grazing pressure for the purpose of protecting the terrestrial component of the riparian community may nonetheless be desirable, since ultimately this will provide assurance for the maintenance of high water quality in the area.

5. <u>The waters of Burro Creek and Francis Creek within this portion of the study area are of excellent chemical quality, and are well-suited for most beneficial uses</u>---In contrast to a previous USBLM assessment that characterized lower Burro Creek waters as less than acceptable for certain uses due to high levels of fecal coliform bacteria, dissolved copper, ammonia, lead, organic nitrogen, and low dissolved oxygen levels (USBLM, 1981), intensive survey sampling revealed no violations of State surface water quality standards and water quality that was consistently better than recommended criteria for a variety of uses (Table 1). Waters in this portion of the study area contained low concentrations of TDS, chloride, fluoride, sulfate, arsenic and manganese, whose concentrations are unacceptably high in many Arizona surface and ground waters. Waters emanating from thermal springs along Francis Creek contained nitrate levels high enough to foster high instream productivity, but which were well below the recommended drinking water limit of 10 mg/l NO_3-N (USPHS, 1962). Heavy metals were largely absent from waters in this reach of the drainage. One sample taken from Francis Creek contained fecal coliform bacteria at levels high enough to be of concern were they to be found on a regular basis, but the contamination proved to be spatially and temporally isolated.

BOULDER CREEK DRAINAGE

A. Description: Boulder Creek rises as Connell Gulch near the Seven-Up Ranch on the Prescott National Forest, west of Camp Wood, Arizona. It flows approximately twenty-seven miles southwesterly to its confluence with Burro Creek west of Bagdad, Arizona. Along its length it receives the waters of several small tributaries, including Warm Springs Creek, Wilder Creek, Butte Creek, and Copper Creek. Boulder Creek and most of its tributaries are ephemeral/intermittent, retreating to permanent pools during dry summer periods.

Mining operations were once abundant in this highly mineralized watershed, and included the Black Pearl, Tungstona, Comstock-Dexter, Kyeke, and Hillside Mines. Only one active mine, Cyprus-Bagdad, remains. Water quality in the drainage has been and continues to be influenced by historic and current mining activity (Rampe, 1982a). Much of the narrative of this section of the report will deal with the effects of mining on Boulder Creek water quality.

During the study, twenty-six sampling stations were established in the drainage, including stations on Wilder, Butte, and Copper Creeks (Figure 12, Table 8). Not all stations were collected during each sampling trip, owing to the creek's seasonal hydrologic variability.

Figure 12.
Boulder Creek

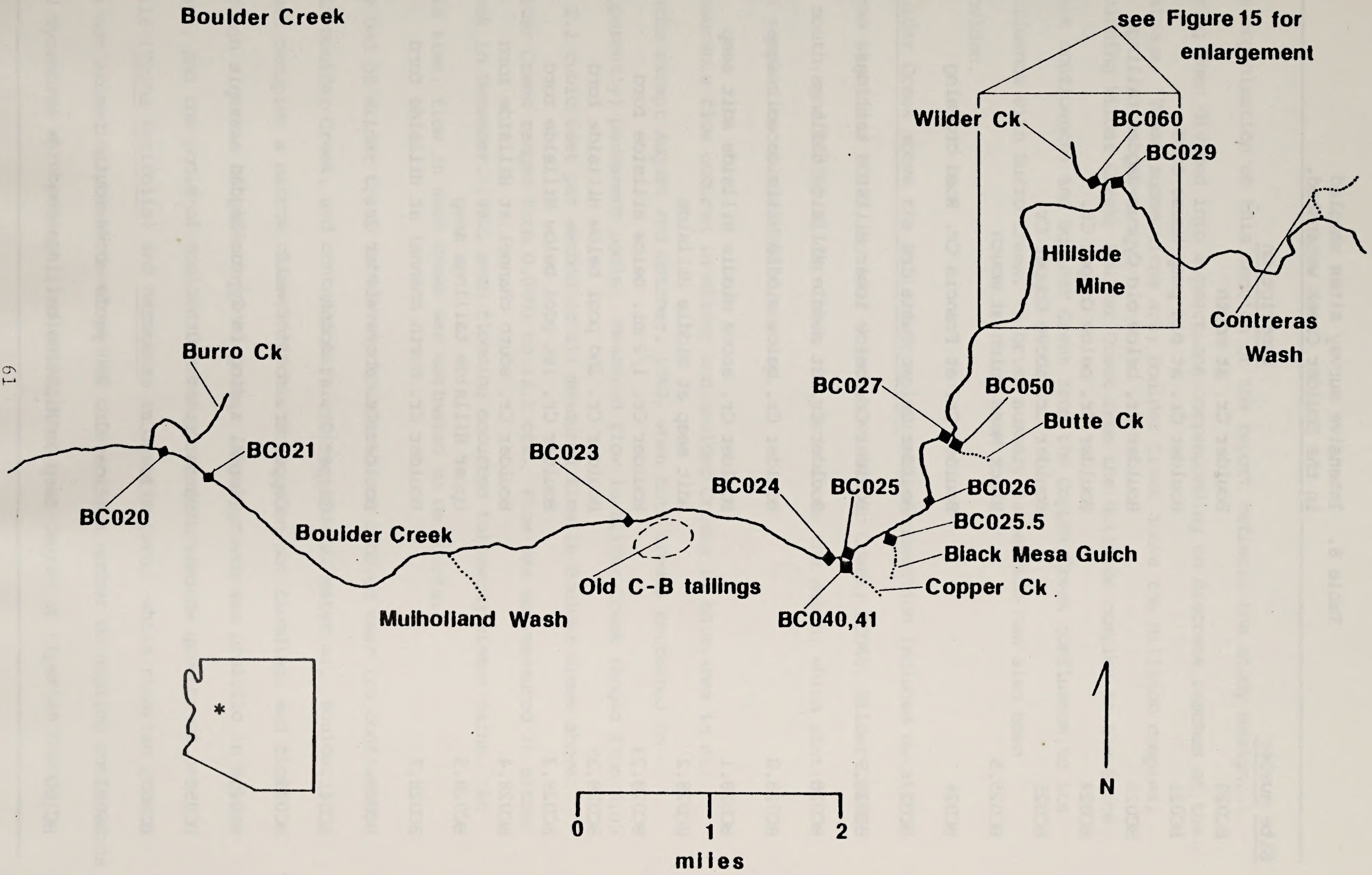


Table 8. Intensive survey sites sampled in the Boulder Creek watershed.

Site number	Description
BC020	Boulder Cr. at mouth
BC021	Boulder Cr. at old pump house ford
BC023	Boulder Cr. below old Cyprus-Bagdad tailings
BC024	Boulder Cr. below Copper Cr.
BC025	Boulder Cr. above Copper Cr.
BC025.5	Black Mesa Gulch at mouth
BC026	Boulder Cr. at Francis Cr. Road crossing
BC027	Boulder Cr. at Butte Cr.
BC027.9	Boulder Cr. below lower Hillside tailings
BC028	Boulder Cr. at middle Hillside tailings
BC028.0	Boulder Cr. below middle Hillside adit seep
BC028.1	Boulder Cr. above middle Hillside adit seep
BC028.2	Adit seep at middle Hillside
BC028.23	Boulder Cr. 1/2 mi. below Hillside ford
BC028.25	Boulder Cr. 2nd pool below Hillside ford
BC028.3	Boulder Cr. 1st pool below Hillside ford
BC028.4	Boulder Cr. south channel at Hillside ford
BC028.5	Upper Hillside tailings seep
BC028.7	Boulder Cr. north channel at Hillside ford
BC029	Boulder Cr. above Wilder Cr.
BC041	Copper Cr. at mouth
BC042	Copper Cr. monitor well
BC045	Thermal spring in Cyprus-Bagdad east pit
BC050	Butte Cr. at mouth
BC060	Wilder Cr. at mouth
BC061	Wilder Cr. 300 yards above mouth
BC100	Seep on Hillside tailings road

The organization of this section of the report reflects the study design, having been divided into subsections corresponding to discrete reaches of the drainage. These subsections are: Boulder Creek above the Hillside complex, including Wilder Creek; Boulder Creek from the Hillside complex to the Butte Creek confluence; and Boulder Creek from the Copper Creek confluence to its confluence with Burro Creek. A brief summary subsection has also been provided.

B. Boulder Creek above the Hillside complex: This subsection includes data from three stations: BC029, Boulder Creek above Wilder Creek; BC060, Wilder Creek at mouth; and BC061, Wilder Creek 300 yards above the mouth, which station was sampled once, when BC060 was dry.

Measurable flow occured in Wilder and Boulder Creeks in this area in all months except August and October, 1982, when both creeks retreated to (apparently) permanent pools. Measured flow in Wilder Creek ranged from 0.05 to 2.1 cubic feet per second (cfs); measured flow in Boulder Creek above Wilder Creek ranged from 0.0001 to 12.2 cfs. Flow was not measured in either creek in December, 1982, when flooding occurred following winter rains. At this time, flow in each creek was estimated to be 50 cfs.

The bed of Wilder Creek is heavily bouldered and cobbled near its confluence with Boulder Creek, and contains little fine alluvial material. Boulder Creek occupies a narrow channel in this area, when not flooding, and flows through a series of bedrock-lined pools. Algal growth was prolific in Wilder Creek, and the pools of Boulder Creek supported streamside growths of cat-tails (Typha latifolia) and Marsilea, an aquatic fern. While riparian growth was not exceedingly well developed in this area, a number of sapling cottonwoods and sycamores were present, indicating that some degree of riparian canopy

replacement was occurring.

Boulder Creek physicochemistry -- Boulder Creek above Wilder Creek is a warm, alkaline desert stream (Table 9). Water temperatures ranged from 4.7°C in February, 1983, to 26.°C in August, 1982. Values for pH in the stream were quite consistent, ranging from 7.3 to 7.9 standard units; the lesser value occurred in December, 1982, when the stream was composed primarily of flood runoff. Suspended solids concentrations were uniformly low when the stream was not in flood, averaging 1.3 mg/l.

Dissolved oxygen levels in Boulder Creek varied seasonally, as did per cent oxygen saturation (Figure 13). During June and August, 1982, when temperatures and observed plant biomass were high, and throughflow in the Boulder Creek pools was low, a pronounced oxygen deficit occurred as respiration and decay processes apparently outstripped primary productivity. Levels of dissolved oxygen fell below 6.0 mg/l, the State surface water quality standard for the protection of warm water fisheries. No stressed fish were observed at this site, though, and recorded oxygen tensions were above those necessary for survival of native fishes found in Boulder Creek (Lowe, et al., 1967).

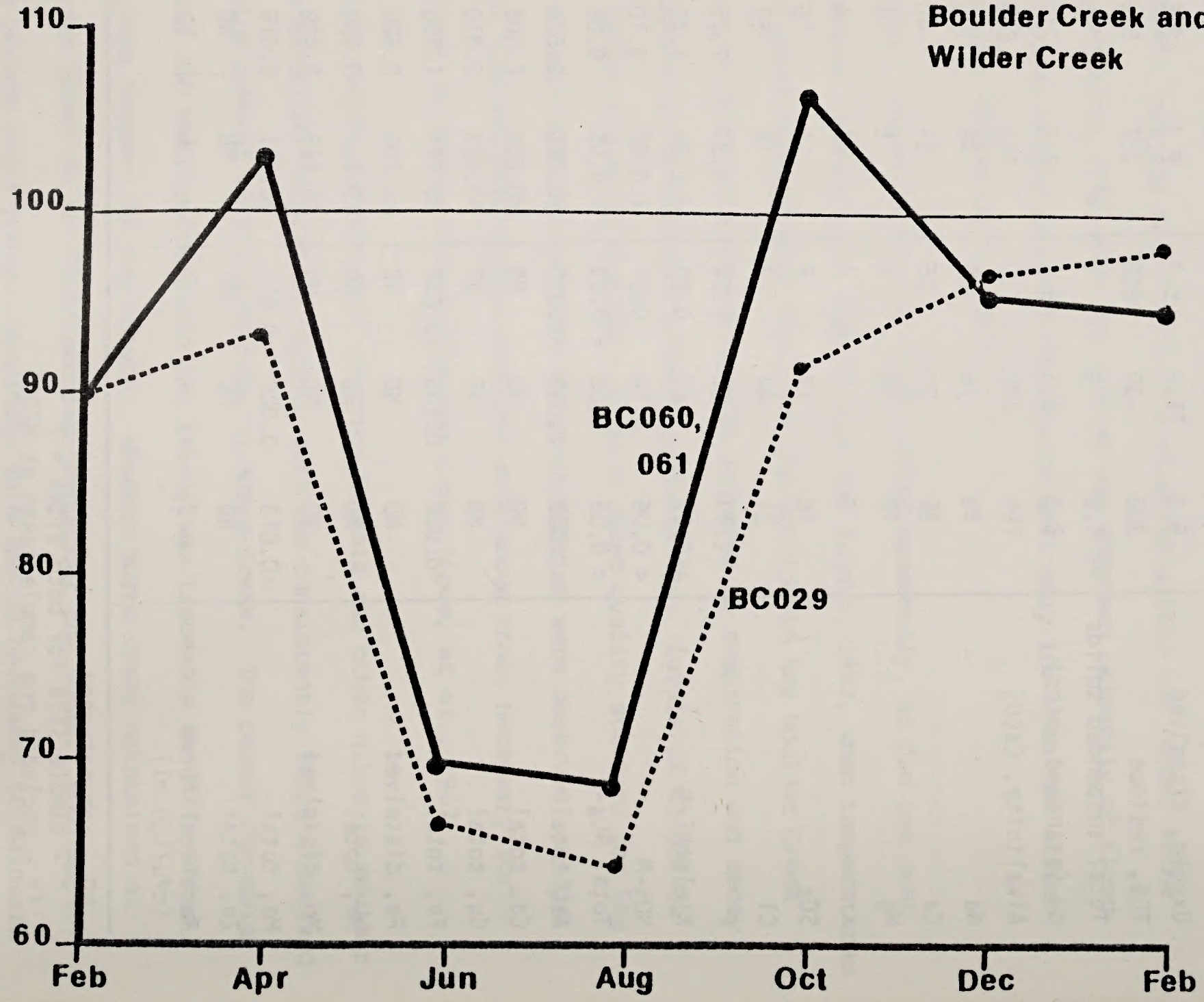
The summertime oxygen deficit that occurred at this and other sites in Boulder Creek (such as BC024) contrasted sharply with the consistently large dissolved oxygen surplus present at the same time in Burro Creek. The reason for this disparity was not readily apparent, but likely was traceable to differences in flow regimes between the two creeks. Whereas Burro Creek maintained at least moderate flows at all sites sampled throughout the summer, Boulder Creek sites became still pools. Continual flow may be necessary to maintain a favorable nutrient flux, which in turn may be needed to support summerlong growth of primary producers. Continual flow would also serve to remove con-

Table 9. Physicochemistry of intensive survey sites sampled in Wilder Creek and Boulder Creek upstream of the Hillside Mine complex. All quantities mg/l except where indicated.

Parameter	Site* BC060** mean	BC060** max	BC060** min	BC029 mean	BC029 max	BC029 min
Temperature (°C)	15	25	6	14	26	5
Oxygen, dissolved	9.0	11.9	5.7	9.4	12.5	5.2
TDS, residue	306	430	228	237	515	83
Total suspended solids	< 1.2	2	< 1	< 2	6	< 1
pH (standard units)	8.3	8.5	8.1	7.6	7.9	7.1
Alkalinity, $CaCO_3$	195	282	119	119	259	18
Na	49	76	25	48	125	6
Ca	38	50	25	21	40	8
Mg	10	19	6	5	11	2
K	6	9	4	2	4	1
SO_4	10	17	5	11	16	3
Cl	21	44	7	18	51	1
F	1.13	1.42	0.74	3.37	7.75	0.85
Kjeldahl-N	< 0.67	1.60	0.20	< 0.74	1.40	< 0.20
NO_3-N	< 0.06	0.14	0.01	< 0.05	0.10	0.01
Total PO_4-P	< 0.05	0.06	< 0.03	< 0.05	0.05	< 0.05
As, total	<0.023	0.033	<0.020	<0.020	0.020	<0.020
Cd, total	ND	ND	ND	<0.005	0.008	<0.005
Cu, total	ND	ND	ND	<0.023	0.010	<0.010
Fe, total	<0.066	0.100	<0.050	<0.574	1.950	<0.050
Fe, dissolved	ND	ND	ND	<0.200	0.620	<0.050
Mn, total	ND	ND	ND	<0.165	0.550	<0.050
Mn, dissolved	ND	ND	ND	<0.125	0.430	<0.050
Mo, total	<0.013	0.020	<0.010	<0.011	0.015	<0.010
Zn, total	ND	ND	ND	ND	ND	ND
Fecal coliforms (cfu/100 ml)	2	4	< 2	6	13	< 3

ND - not detected
* - sample size for both sites = 7
** - includes one sample taken at BC061

Figure 13.
Dissolved Oxygen, % saturation
Boulder Creek and
Wilder Creek



centrations of decay products that may limit growth and place a further demand on available oxygen.

Chemically, Boulder Creek above Wilder Creek was dominated by sodium and bicarbonate, with appreciable levels of calcium and chloride (Table 9). Total dissolved solids (TDS) in the creek varied seasonally and in response to flow, reaching a maximum concentration of 515 mg/l in August (Figure 14). Whereas these TDS levels are probably not unusual for intermittent desert streams in summer, they do exceed the U.S. Public Health Service's recommended drinking water limit for TDS (USPHS, 1962).

Trace metals at this site were generally present at low concentrations. Measurable levels of iron and manganese occurred during summer; the presence of these metals was probably due to concentration via evaporation, though bacterial activity and low oxygen levels may have been partially responsible for liberation of these elements into the water column. Cadmium, copper, and molybdenum were occasionally found here in measurable amounts, though not at levels exceeding applicable State surface water quality standards. Flood waters collected in December, 1982 contained amounts of total trace metals that were generally below detection limits, indicating the lack of significant sources for particulate metals immediately upstream in the Boulder Creek drainage.

Kjeldahl nitrogen was the dominant nitrogen form in Boulder Creek above Wilder Creek, averaging 0.7 mg/l as N. The highest Kjeldahl nitrogen concentration (1.4 mg/l) occurred in association with the December, 1982 flooding. Aside from this, no seasonal trends in Kjeldahl nitrogen levels were evident. Nitrate nitrogen levels in this stretch of Boulder Creek were uniformly low and were often below laboratory detection limits (0.1 mg/l as N). The highest measured concentration of nitrate nitrogen was 0.4 mg/l, observed in October,

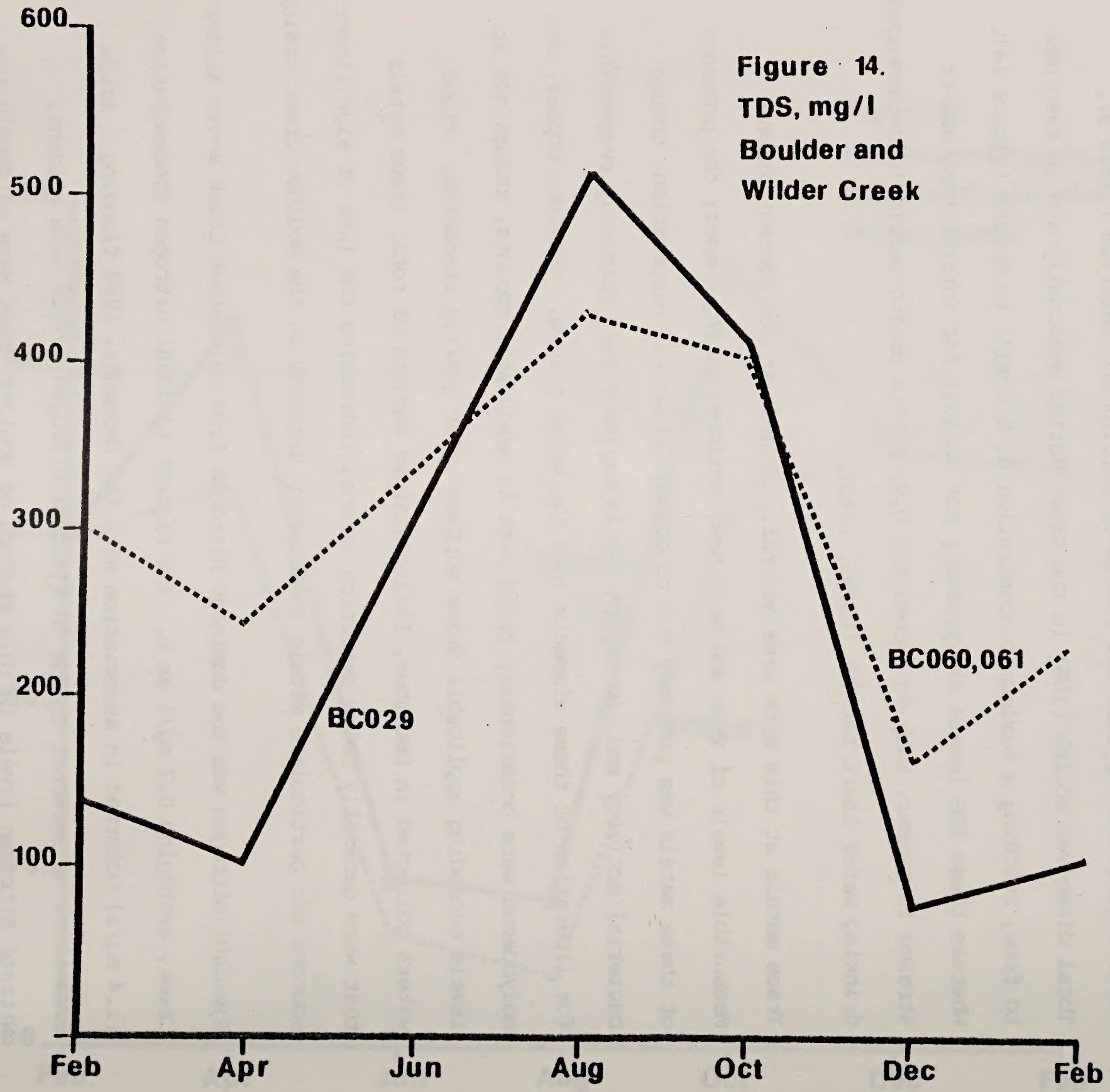


Figure 14.
TDS, mg/l
Boulder and
Wilder Creek

1982. No obvious seasonal trends occurred in the nitrate nitrogen data.

Total and ortho-phosphorus concentrations at this site were usually below laboratory detection limits (0.05 mg/l as P for total phosphorus and 0.01 mg/l as P for ortho-phosphorus). High levels recorded for August, 1982 were likely laboratory artifacts, as discussed on page 10. Ortho-phosphorus was detected in December, 1982 (0.04 mg/l) and February, 1983 (0.02 mg/l). The average ratio of total nitrogen to total phosphorus at this site was greater than 14.0, indicating that phosphorus is likely to be the single most limiting nutrient to plant growth in upper Boulder Creek (Gerloff and Skoog, 1954). Nitrate, a readily useable nitrogen form, also was scarce in these waters, however, indicating that the biotic community in the creek placed a strong demand on available nitrogen.

Fecal coliform bacteria were not detected at this site during winter months. A maximum population level of 15 colony forming units/100 ml was found in August, 1982. This level was far below applicable State surface water quality standards. The presence of these low levels of bacteria was likely attributable to livestock and wildlife.

Wilder Creek physicochemistry--The physicochemical characteristics of Wilder Creek were similar to those of Boulder Creek (Table 9). Water temperatures ranged from 5.2°C in December, 1982 to 25.0°C in August. The pH of Wilder Creek was consistently higher than that of Boulder Creek, and varied from 7.9 to 8.7 standard units, the lower value occurring during the high runoff period in December, 1982. Total suspended solids levels in the creek were less than 2 mg/l during base flow periods.

Dissolved oxygen concentrations and per cent oxygen saturation varied seasonally in Wilder Creek, and exhibited a summertime oxygen deficit similar to that observed in Boulder Creek. Oxygen levels fell below 6.0 mg/l in June and August, 1982, but did not appear to stress resident fish or other aquatic life. As with Boulder Creek, the stagnation of Wilder Creek's waters with the onset of summer was the likely cause of the oxygen depression.

Wilder Creek, like Boulder Creek, was dominated chemically by sodium and bicarbonate. Subtle differences existed between the ionic compositions of the two waters, however. Calcium, magnesium, and chloride were more abundant in Wilder Creek than in the waters of upper Boulder Creek. Potassium and fluoride were likewise more concentrated in Wilder Creek, the latter ion occurring in amounts that would serve to compromise the creek's suitability as a drinking water source without treatment for fluoride reduction (USPHS, 1962). Fluoride reached 1.65 mg/l in creek waters in October. The high pH of the creek allowed the presence of the carbonate ion in several samples (Cole, 1975).

Total dissolved solids levels in Wilder Creek varied seasonally in response to variations in flow and evaporation rates, the highest dissolved solids concentrations (432 mg/l) occurring in August, 1982 (Figure 14). The observed variation in Wilder Creek was not as great as that in Boulder Creek at BC029, however. This relative chemical stability implies that inflow from springs is more important in this reach of Wilder Creek than in upper Boulder Creek, the chemistry of which system is apparently defined primarily by runoff and evaporative processes.

Trace metal levels in Wilder Creek were generally lower than in Boulder Creek at BC029. Iron was present at measurable concentrations only during flooding

in December, 1982, when it was transported in association with suspended sediments. Manganese, copper, and cadmium, present in low concentrations in upper Boulder Creek, were found in trace amounts in several samples in Wilder Creek, and measurable total arsenic occurred in the sample collected in August, 1982, when the concentration reached 33 ug/l. This arsenic concentration is less than the applicable State surface water quality standard as well as EPA's ambient water quality criterion for freshwater life (USEPA, 1980b). Dissolved lead concentrations in Wilder Creek had been reported previously (Runnells, 1981) to be in excess of 50 ug/l. These results were not confirmed by this study, during which neither dissolved nor total lead concentrations exceeded the laboratory detection limit of 20 ug/l.

Kjeldahl nitrogen in Wilder Creek averaged 0.7 mg/l, and showed no seasonal patterns. Nitrate nitrogen levels were low, reaching a maximum of 0.13 mg/l in August, 1982, and also did not appear to have a seasonal variation pattern. Phosphorus appeared to be more abundant in Wilder Creek than in Boulder Creek, reaching measurable concentrations in February and December, 1982, and February, 1983. Phosphorus was nonetheless scarce relative to nitrogen, suggesting that Wilder Creek, like Boulder Creek, is a potentially phosphorus-limited system. Wilder Creek supported large amounts of periphyton biomass however, fostered by warm water temperatures and high insolation rates. If phosphorus limitation ever occurs in Wilder Creek, it does so only after a great deal of primary production has taken place.

Fecal coliform bacteria were practically nonexistent in Wilder Creek during the study. A maximum of 4 cfu/100 ml was found during August, 1982.

C. Boulder Creek: Hillside Mine to Butte Creek Confluence

This reach of Boulder Creek includes the most important source of heavy metal

pollution in the Burro Creek study area, namely, the abandoned Hillside Mine and its associated tailings piles. This area was the object of intense scrutiny during the study. A total of 12 sampling sites were established here (Figure 15).

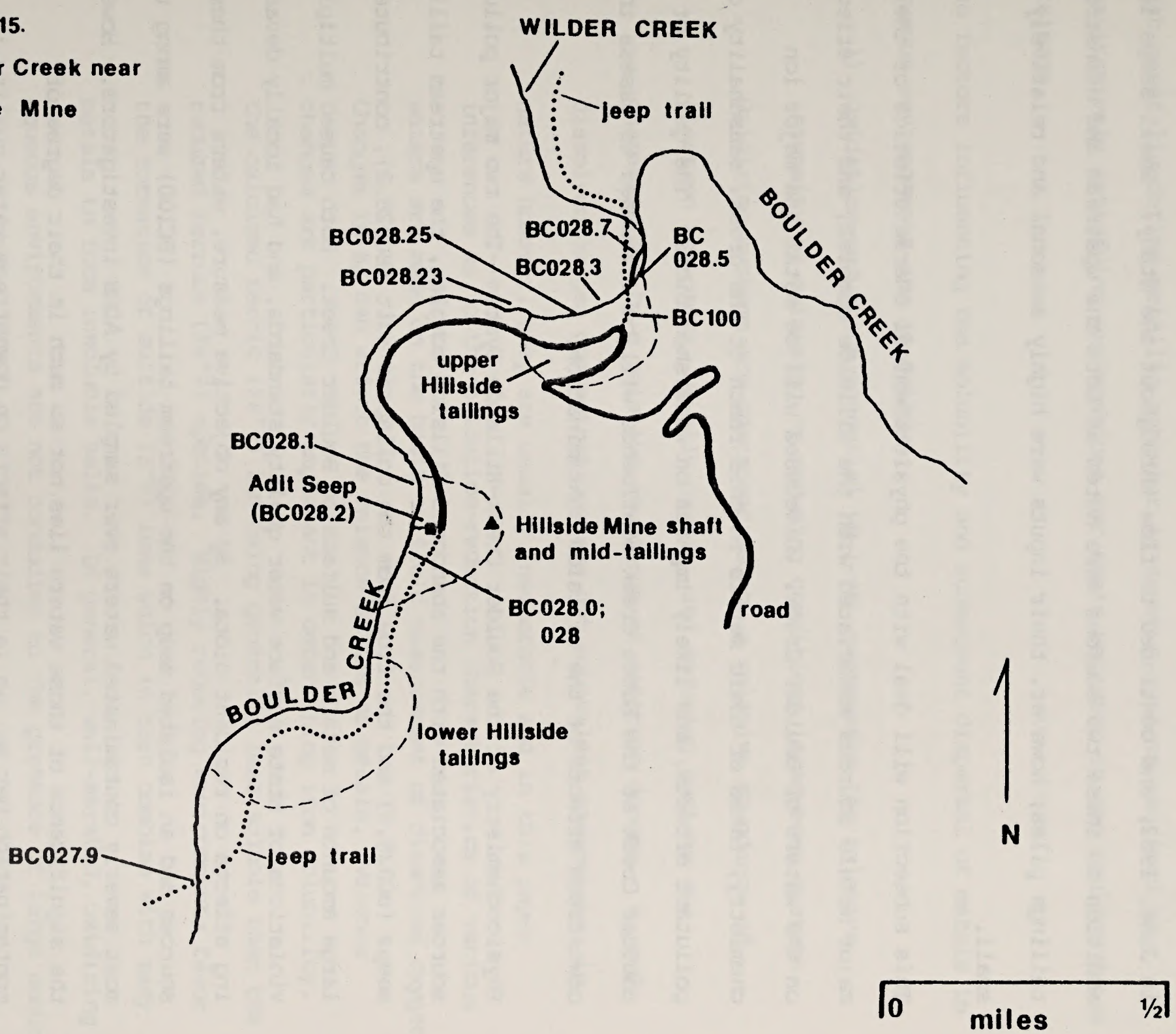
The Hillside complex included an underground gold mine and milling operation and was active until the 1950's. According to local accounts, custom milling was performed at the Hillside for small mining operations in the area, which brought various types of ores there for processing. Presumably, milling was performed on ores which bore commercially extractable quantities of nickel, zinc, tungsten, silver, and copper, in addition to gold. Many ores in the area also contain significant amounts of arsenic, which is a common component of local metal sulfide ores, as well as antimony and radionuclides. The disposal of these varied milling wastes on the banks of Boulder Creek created severe water quality problems as toxic elements were leached and carried in particulate form from the tailings and released into the creek's waters. The abundance and variety of metals and ligands in the Hillside seepage, combined with the area's hydrologic complexity, present difficulties with regard to biogeochemical interpretation of the system, and with regard to selection of regulatory and mitigative alternatives.

The Hillside complex is composed of three elements: an upstream tailings pile, the abandoned mine and associated waste dump, and a downstream tailings pile. While all three of these elements had recognizable negative effects on Boulder Creek water quality, two pollutant sources were particularly important during the course of the study. One was a series of seeps (site BC028.5) at the upstream end of the upstreams tailing pile, which discharged highly acidic, metal-laden water into the creek. The second source emanated

Figure 15.

Boulder Creek near

Hillside Mine



from what was apparently a collapsed adit at the abandoned mine. Flow from this source was rich in arsenic and reduced iron. This discharge first appeared in June, 1982, and continued to flow throughout the study. Small seeps in addition to these two sources were noted at both the upstream and downstream tailings piles; however, their inputs were highly seasonal and relatively small.

This subsection will deal with the physicochemical characteristics of the two major metals sources associated with the Hillside complex, and their effects on the waters of Boulder Creek. Discussed will be metal and major ion chemistry, fates of toxic metals in this reach of the creek, seasonality of pollutant effects, and likely impacts on watershed biota. The quality of Boulder Creek at the Butte Creek confluence will be discussed to assess the downstream effects of the Hillside contamination.

Physicochemistry of the Boulder Creek-Hillside System--The two major pollution sources associated with the abandoned Hillside complex, the upstream tailings seeps (BC028.5) and the flow from the collapsed adit (BC028.2), contributed large amounts of metals and sulfate to Boulder Creek. Both caused multiple violations of State surface water quality standards, and had locally devastating effects on resident biota. By any objective measure, waters from these sources and an isolated seep on the upstream tailings (BC100) were among the most severly contaminated waters ever sampled by ADHS investigators. However, the significance of those waters lies not so much in their degree of contamination per se, as in their effects on downstream water quality in Burro and Boulder Creeks. To understand these effects, the processes influencing the dispersal of those contaminants of most concern in the seeps, the toxic heavy metals, must also be understood to some degree. While an

exact understanding of the reactions occuring in a complex system like Hillside-Boulder Creek is as yet beyond our ken, an understanding of processes that generally define metallic behavior in aqueous systems can lead to qualitatively satisfying explanations for their behavior in the Boulder Creek drainage.

The factors influencing the solubility and subsequent dispersal of metals in aqueous environments are as follows:

1) Oxidation-reduction potential (E_h)--E_h represents the relative intensity of oxidizing or reducing conditions in aqueous systems. Oxidizing systems are characterized by a relative abundance of electron acceptors, usually oxygen, and reducing systems are characterized by a relative abundance of electron donors. E_h and dissolved oxygen concentrations are not equivalent parameters; in nature however, they are usually inseparable and in this paper inferences as to the oxidation-reduction characteristics of various waters are made on the basis of field measurement of dissolved oxygen. Changes in E_h can effect the valence states of metals. Valence changes are particularly important in determining iron solubility, the oxidized ferric (Fe^{+3}) ion being generally less soluble than the reduced ferrous (Fe^{+2}) species. Highly reducing environments favor the formation of sulfide (S^{-2}) ions which in turn combine with many metals to form insoluble salts. In general, well-aerated, oxidizing aqueous environments are not conducive to the presence of large amounts of dissolved metals. Exceptions are afforded by arsenic, molybdenum, and chromium, among others, which form stable oxidized anions (e.g., AsO_4^{-3}) that may be widely dispersed in aquatic systems.

2) pH--The pH of aqueous systems is of prime importance in determining metal solubility. Many metallic salts (e.g., $Fe_2(SO_4)_3$) that are insoluble in neutral or alkaline solutions may be soluble in acidic waters (contrarily, molybdenum salts tend to be more easily dissolved in alkaline waters than in slightly acidic ones). Low pH (high acidity) interferes with many of the processes that serve to remove metals from solution. Hydrolysis, spontaneous oxidation, and sorption onto metal oxides and clays are inhibited at low pH, proceeding at geometrically faster rates for most metals as neutrality is approached (Andelman, 1974). Metals vary in their reactions to pH changes; iron and aluminum were the most sensitive in the study system, their concentrations changing rapidly with relatively small changes in pH. In the pH range of 2 to 9 (that encountered in the study), the solubilities of most metals decrease with increasing pH. Exceptions again are afforded by those metals that form stable oxidized anions, which are mobile over the pH ranges found in natural waters.

3) Hydrolysis--Hydrolysis is the process by which charged metal ions in solution attract, then split, water molecules, forming metal hydroxides, which are often insoluble, and free hydrogen ions. A simplified reaction follows:

$$Me^{+x} + XH_2O = XH^{+} + Me(OH)_x\ (s) \qquad (1)$$

Such reactions are highly pH dependent and are inhibited by a surfeit of hydrogen ions. Hydrolysis was likely an important process in limiting the solubility of iron, aluminum, and copper in the study system.

4) Precipitation--Many dissolved anionic species (ligands) form salts with specific metals that are insoluble over wide ranges of pH and

E_h. The precipitation of dissolved silver by halides is a well-known example. In the study system, sulfate may exert partial control over iron solubility, and carbonate may be finally limiting over free copper. Many lead salts are exceedingly insoluble, accounting for this metal's absence from all but the strongest tailing solutions (Richard and Nriagu, 1979).

5) Coprecipitation--Metallic species that would otherwise be stable in a dissolved state may be incorporated into precipitate matrices formed by hydrolysis and oxidation reactions entered into by other metals. The most important example of coprecipitation in the study system is afforded by arsenic and iron. Arsenate (AsO_4^{-3}) is stable and highly mobile in aerated aquatic systems, and therefore a potentially dangerous contaminant (NRC, 1977). Arsenate is readily incorporated in the hydrolysis reaction of iron, however, forming insoluble ferric hydroxyarsenate and placing an effective solution control on this toxic element. Incorporation into manganese oxide matrices may limit the solubilities of copper, zinc, and other metals, and molybdate may also be subject to removal via coprecipitation (Stumm and Morgan, 1981).

6) Sorption--Sorption is the reversible binding of dissolved metals to charged surfaces. Clay particles probably represent the most important source of binding sites for metals in aquatic systems, but metallic oxy- and hydroxy-precipitates, organic molecules, and rock fractures all provide environments onto which dissolved metals can be sorbed (Rubin, 1974). Sorption is highly pH dependent, as hydrogen ions compete with positively charged metals for binding sites. Metals and other cations are sorbed differentially, largely in

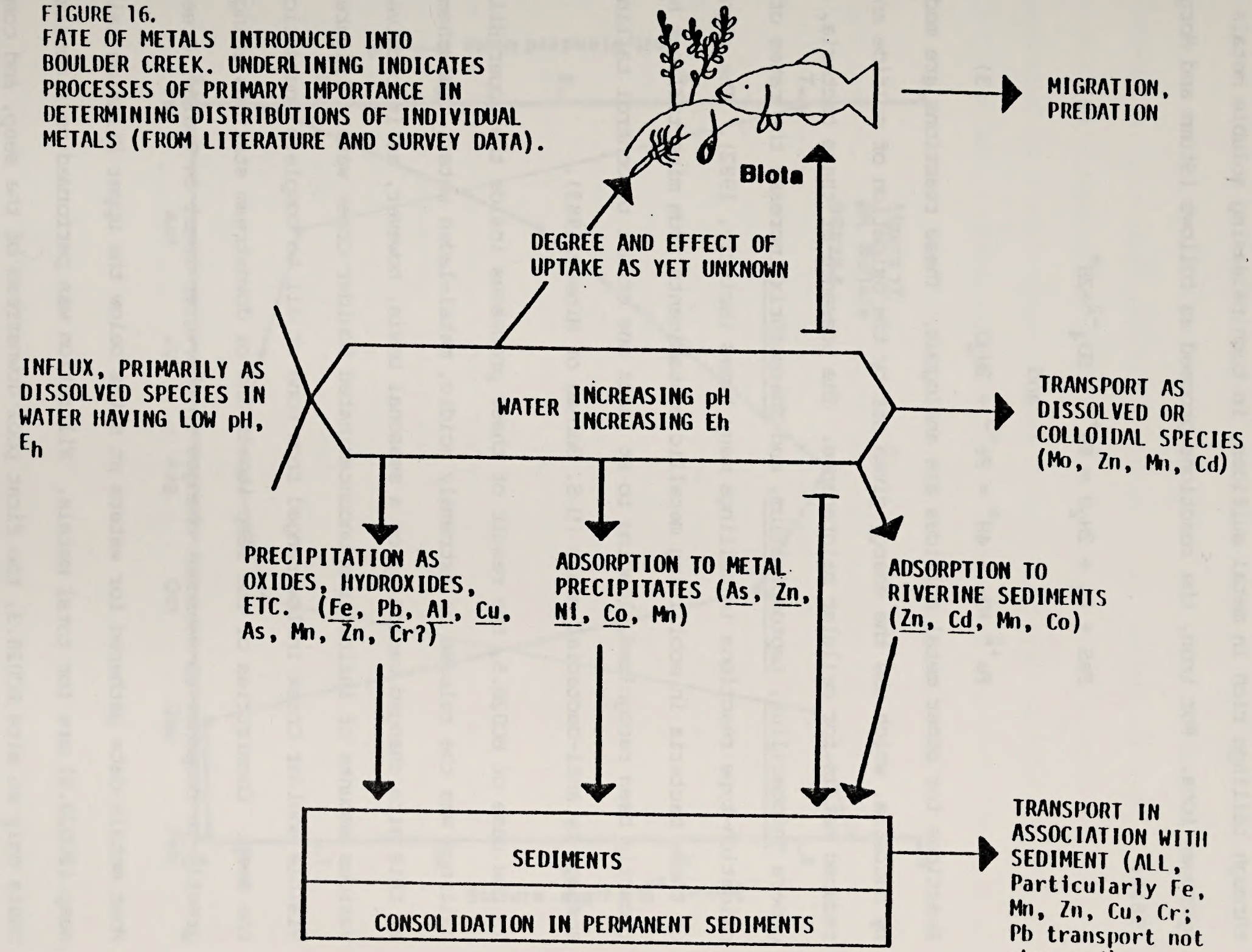
response to varying charge to volume ratios of the different ions in aqueous solution (Millot, 1970). Relatively soluble metals, which escape other solution constraints, may be primarily limited in natural systems by sorption phenomena. Zinc is perhaps the best relevant example of such a metal (USEPA, 1980j), and cadmium concentrations may also be limited in this way (USEPA, 1980c).

7) Biological--Bacterial transformations of metals, other than those mentioned hereinafter as taking place in tailings, are known to occur under certain circumstances. Bacteria can methylate metals such as arsenic, cadmium, and lead, and the resulting organometals are generally extremely toxic. Little information is available, however, to assess the potential importance of these transformations in nature. Other aquatic organisms may accumulate metals through absorption onto surficial mucus, by ingestion of water or sediments, or by ingestion of contaminated organisms. The amounts of metals that are taken up by organisms in this system are probably extremely small compared to those that are routed through other pathways already discussed (precipitation, sorption, etc.). The potential effects of excessive metal exposure on riparian biota are of great concern, however, and will be dealt with in a subsequent section.

A summary of the above factors is presented in Figure 16, which is a simplified version of a biogeochemical cycle for the heavy metals of importance in the Hillside-Boulder Creek system.

The seep at the upstream end of BC028.5 manifested chemistry typical of copper mine drainage in Arizona from current and abandoned operations (Dean, 1982; Lampkin, 1980; Love, 1980). In such situations, oxygenated water percolated

FIGURE 16.
FATE OF METALS INTRODUCED INTO BOULDER CREEK. UNDERLINING INDICATES PROCESSES OF PRIMARY IMPORTANCE IN DETERMINING DISTRIBUTIONS OF INDIVIDUAL METALS (FROM LITERATURE AND SURVEY DATA).



through tailings rich in metal sulfides, in turn releasing soluble metals and hydrogen ions. For iron, the reactions proceed as follows (Stumm and Morgan, 1981):

$$FeS + O_2 + 2H_2O = Fe^{+2} + SO_4^{-2} + 2H^+ \qquad (2)$$

and

$$Fe^{+2} + O_2 + 4H^+ = Fe^{+3} + 2H_2O \qquad (3)$$

Reactions for other metal sulfides are analogous. These reactions are mediated by bacteria, which use the energy given off by the oxidation of sulfide and reduced metals for cellular maintenance. The presence of these bacteria, of the genera Thiobacillus, Leptospirillum, and Thermothrix increase the rates of pyritic oxidation-type reactions in tailings many times (Brierly, 1982). The significance of these bacteria in mobilizing metallic contaminants from mine tailings has recently been recognized, leading to at least one effort to control tailings seepage by anti-bacterial means (U.S. Bureau of Mines, 1983).

In the case of BC028.5, the result of these processes inside the upper Hillside tailings was the release of extremely acidic, metal-laden water. The chemistry at this site changed radically on a seasonal basis, however, as it received various amounts of inflow from uncontaminated Boulder Creek waters (Figure 17). Visible Boulder Creek inflow ranged from none at all to complete inundation of the seep. Chemistries of the seep itself and of downstream stations changed greatly in response to seasonal changes in the water level in Boulder Creek.

Most metals data gathered for waters at sites below the upper Hillside tailings seep (BC028.5) are for total metals. Filtration was performed on a consistent basis only at site BC028.3, the first pool downstream of the seep, and comparison of filtered vs. unfiltered samples showed that most of the metals present in the water column during periods of low throughflow in Boulder Creek (i.e., June-October

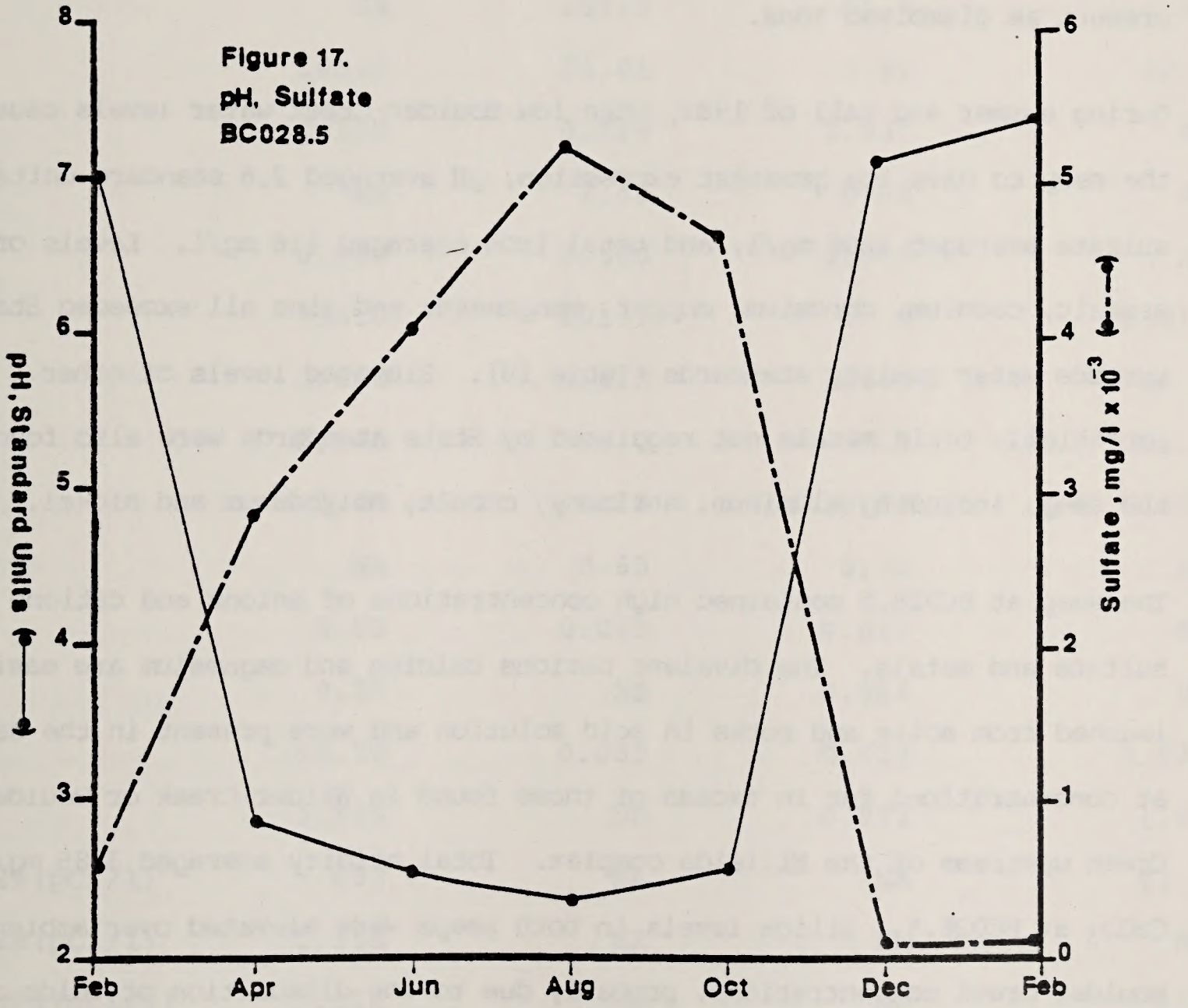


Figure 17.
pH, Sulfate
BC028.5

were present in the dissolved state. Turbidity values also tended to be low during this time, lending further credence to the interpretation that most metals in the water during low flow were dissolved, rather than adsorbed onto suspended materials. Thus, many of the statements made in the ensuing discussion (such as those referring to water quality violations) have implicit in them the assumption that metals in the water column were substantially present as dissolved ions.

During summer and fall of 1982, when low Boulder Creek water levels caused the seep to have its greatest expression, pH averaged 2.6 standard units, sulfate averaged 4606 mg/l, and total iron averaged 416 mg/l. Levels of arsenic, cadmium, chromium, copper, manganese, and zinc all exceeded State surface water quality standards (Table 10). Elevated levels of other potentially toxic metals not regulated by State standards were also found in the seep, including aluminum, antimony, cobalt, molybdenum and nickel.

The seep at BC028.5 contained high concentrations of anions and cations besides sulfate and metals. The divalent cations calcium and magnesium are easily leached from soils and rocks in acid solution and were present in the seeps at concentrations far in excess of those found in Wilder Creek or Boulder Creek upstream of the Hillside complex. Total acidity averaged 3885 mg/l as $CaCO_3$ at BC028.5. Silica levels in both seeps were elevated over ambient Boulder Creek concentrations, probably due to the dissolution of feldspars by acidic tailings seepage, a process that releases soluble silicates and monovalent cations (Hem, 1970).

Dissolved oxygen was measured only once at BC028.5, in June, as it was feared that the extremely low pH of the seep would cause instrument damage. At that time, dissolved oxygen was quite abundant (7.5 mg/l). Under such conditions,

Table 10. Maximum observed values of acidity, sulfate and heavy metals, along with minimum pH values at highly contaminated Boulder Creek intensive survey sites. All values total 1 mg/l except where noted.

Parameter	Site* BC100	BCO28.5	BCO28.3	BCO28.2
pH	2.5	2.4	2.7	5.4
H^+,$CaCO_3$	NA	4,243	1,234	NA
SO_4	102,606	5,239	2,398	1,485
Al	NA	255.5	91.4	NA
As	163.4	34.01	0.91	20.6
Cd	0.100	0.029	0.037	ND
Co	NA	2.40	0.88	NA
Cr	0.990	0.300	0.074	NA
Cu	750.0	101.1	37.2	0.013
Fe	3,800	613.2	108.0	68.0
Mn	1,160	66.0	47.9	64.0
Mo	3.47	0.28	0.09	0.064
Ni	NA	0.63	0.32	NA
>Se	0.50	0.061	0.014	ND
Pb	0.27	ND	0.014	ND
Sb	99.70	0.080	0.029	0.022
U	3.980	ND	0.003	1.00
Ra-226(pCi/l)	893	NA	NA	61.8
Ra-228(pCi/l)	1,550	NA	NA	ND
gross α(pCi/l)	3,018	ND	ND	657
gross β(pCi/l)	4,366	ND	ND	282
Zn	1,290	500	192.5	9.50

NA - not analyzed; ND - not detected

* sample size for BC100 = 1; sample size for BC028.5 = 7; sample size for BC028.3 = 6; sample size for BC028.2 = 4.

iron was probably present mostly in the ferric form (as predicted by equation 3), arsenic was present as arsenate, and sulfur as sulfate. The presence of large quantities of metals in seep water was maintained in this case by low pH rather than low E_h, which prevented sorption, inhibited hydrolysis and oxidation, and kept salts like ferric sulfate in solution. The subsequent downstream precipitation of metals in Boulder Creek can thus be attributed primarily to increases in pH.

In summer and fall of 1982 (August and October), pH increases at sites in Boulder Creek downstream of BC028.5 took place very slowly as a result of contact with bed material and apparent mixing with upstream alluvial flow from Boulder Creek (Figure 18). The creek had at the time retreated to a series of isolated pools, connected apparently by some amount of alluvial throughflow. In October, the partitioning of these pools led to the formation of discrete chemistries within each, which were extensively characterized by laboratory analysis. Each pool also took on a different color. BC028.5 was transparent, and the color of coffee. BC028.3, immediately downstream, was murky brick-red, with an orange bottom. Pool BC028.25 was clear azure-blue, its bottom covered with white flocculent material. Pool BC028.23, farthest downstream, was clear green, the bottom again covered with white, amorphous floc. The colors were due to chemical constituents, as all pools were apparently devoid of plant and animal life, but it is unknown whether they were caused by actual staining by metal ions or the refractive properties of suspended precipitates.

The slow rise in pH in these pools allowed close observation of the behavior of various metals in the face of decreasing acidity. Of the most abundant heavy metals in the BC028.5 seep (Al, Cu, Fe, Mn, and Zn), iron was the

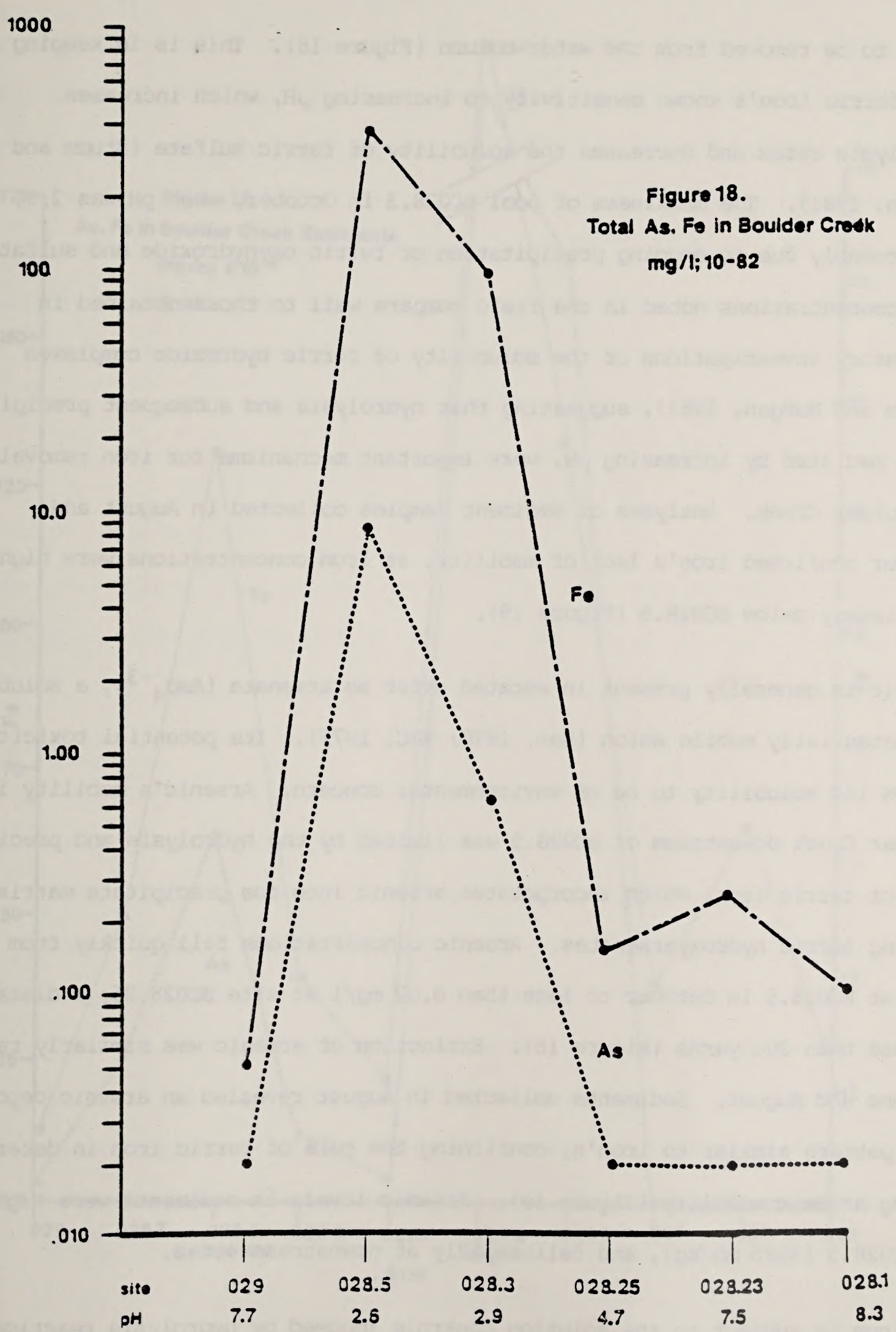


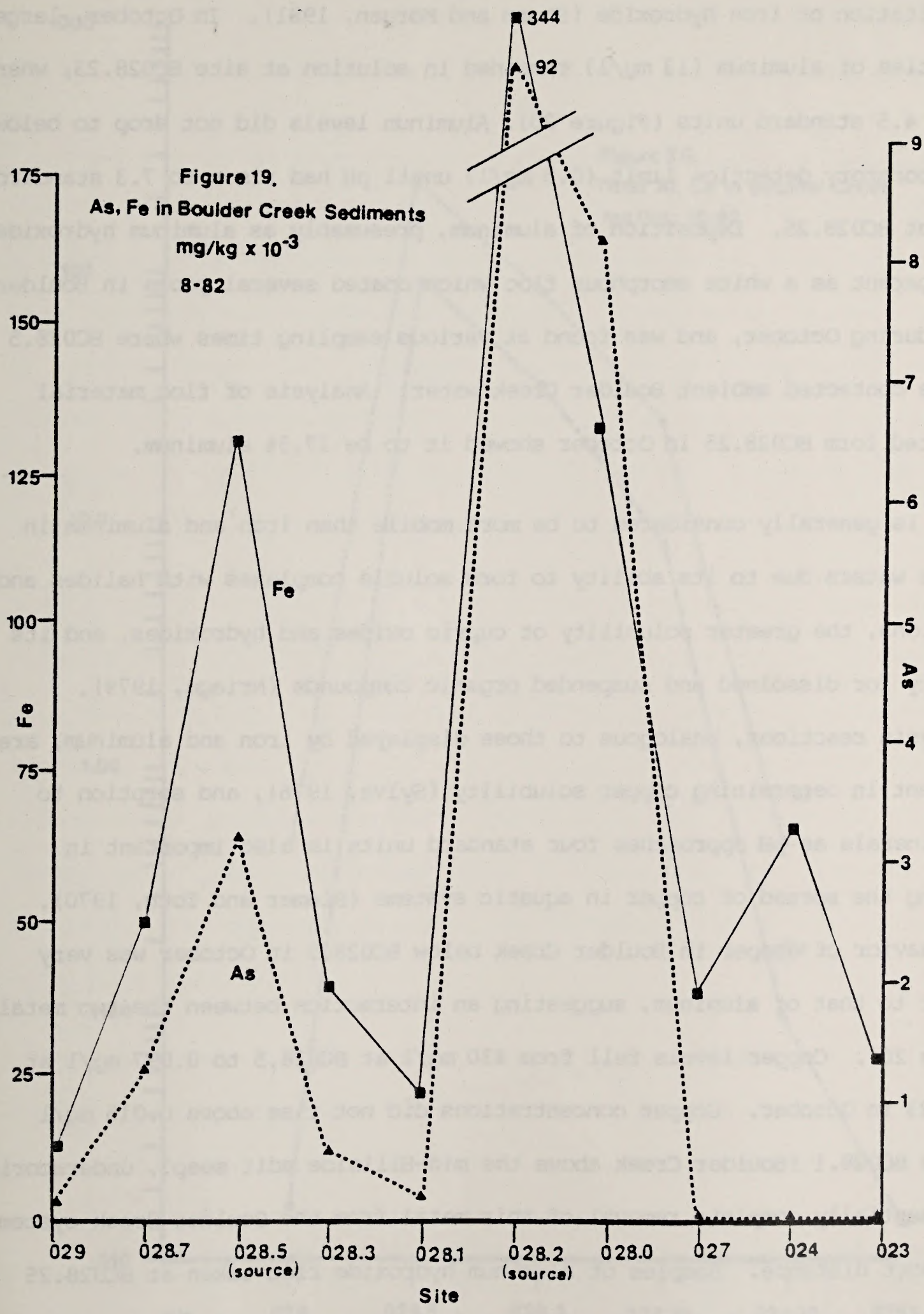
Figure 18.
Total As. Fe in Boulder Creek
mg/l; 10-82

first to be removed from the water column (Figure 18). This is in keeping with ferric iron's known sensitivity to increasing pH, which increases hydrolysis rates and decreases the solubility of ferric sulfate (Stumm and Morgan, 1981). The murkiness of pool BC028.3 in October, when pH was 2.9, was probably due to ongoing precipitation of ferric oxyhydroxide and sulfate. Iron concentrations noted in the field compare well to those obtained in laboratory investigations of the solubility of ferric hydroxide complexes (Stumm and Morgan, 1981), suggesting that hydrolysis and subsequent precipitation, mediated by increasing pH, were important mechanisms for iron removal in Boulder Creek. Analyses of sediment samples collected in August and October confirmed iron's lack of mobility, as iron concentrations were high immediately below BC028.5 (Figure 19).

Arsenic is generally present in aerated water as arsenate (AsO_4^{-3}), a soluble and potentially mobile anion (Hem, 1970; NRC, 1977). Its potential toxicity causes its solubility to be of environmental concern. Arsenic's mobility in Boulder Creek downstream of BC028.5 was limited by the hydrolysis and precipitation of ferric iron, which incorporates arsenic into the precipitate matrix, forming ferric hydroxyarsenates. Arsenic concentrations fell quickly from 7.1 mg/l at BC028.5 in October to less than 0.02 mg/l at site BC028.25, a distance of less than 200 yards (Figure 18). Extinction of arsenic was similarly rapid in June and August. Sediments collected in August revealed an arsenic deposition pattern similar to iron's, confirming the role of ferric iron in determining arsenic mobility (Figure 19). Arsenic levels in sediments were highest at BC028.5 (3195 mg/kg), and fell rapidly at downstream sites.

Aluminum is subject to the solution controls imposed by hydrolysis reactions, but precipitation of aluminum hydroxides takes place at higher pH than does the

Figure 19.
As, Fe in Boulder Creek Sediments
mg/kg x 10^{-3}
8-82



precipitation of iron hydroxide (Stumm and Morgan, 1981). In October, large quantities of aluminum (13 mg/l) remained in solution at site BC028.23, where pH was 4.5 standard units (Figure 20). Aluminum levels did not drop to below the laboratory detection limit (0.5 mg/l) until pH had risen to 7.3 standard units at BC028.25. Deposition of aluminum, presumably as aluminum hydroxides, was apparent as a white amorphous floc which coated several pools in Boulder Creek during October, and was found at various sampling times where BC028.5 seepage contacted ambient Boulder Creek water. Analysis of floc material collected form BC028.25 in October showed it to be 17.5% aluminum.

Copper is generally considered to be more mobile than iron and aluminum in surface waters due to its ability to form soluble complexes with halides and other ions, the greater solubility of cupric oxides and hydroxides, and its affinity for dissolved and suspended organic compounds (Nriagu, 1979). Hydrolysis reactions, analogous to those displayed by iron and aluminum, are important in determining copper solubility (Sylva, 1976), and sorption to clay minerals as pH approaches four standard units is also important in limiting the spread of copper in aquatic systems (Riemer and Toth, 1970). The behavior of copper in Boulder Creek below BC028.5 in October was very similar to that of aluminum, suggesting an interaction between the two metals (Figure 20). Copper levels fell from 430 mg/l at BC028.5 to 0.097 mg/l at BC028.23 in October. Copper concentrations did not rise above 0.015 mg/l at site BC028.1 (Boulder Creek above the mid-Hillside adit seep), underscoring the essentially complete removal of this metal from the Boulder Creek system in a short distance. Samples of aluminum hydroxide floc taken at BC028.25 in October were enriched in copper, containing a concentration of 14,700 mg/kg Cu, far higher than at any other site (Figure 21). This suggests that copper was incorporated into the aluminum hydroxide matrix, limiting its

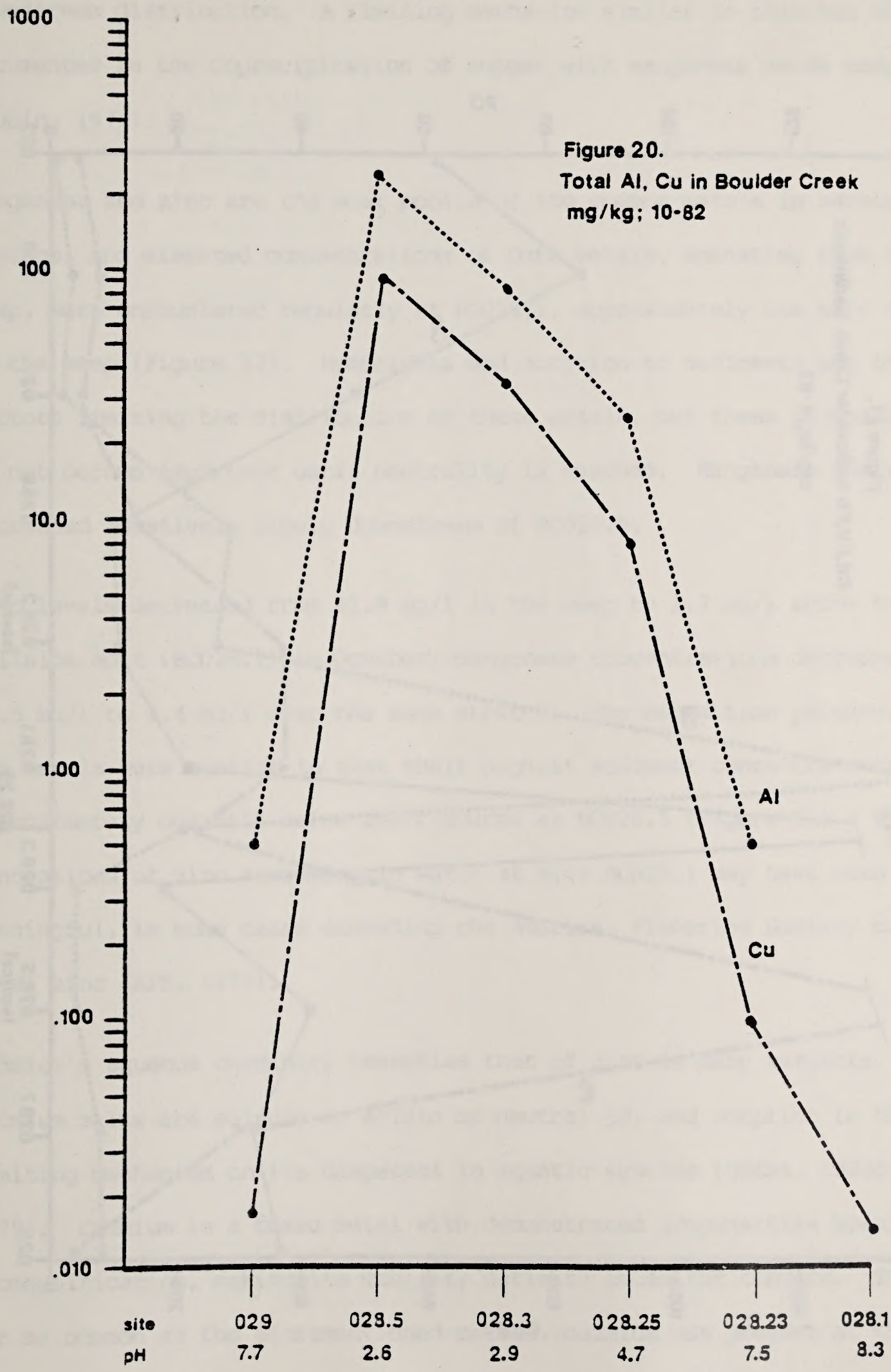


Figure 20.
Total Al, Cu in Boulder Creek
mg/kg; 10-82

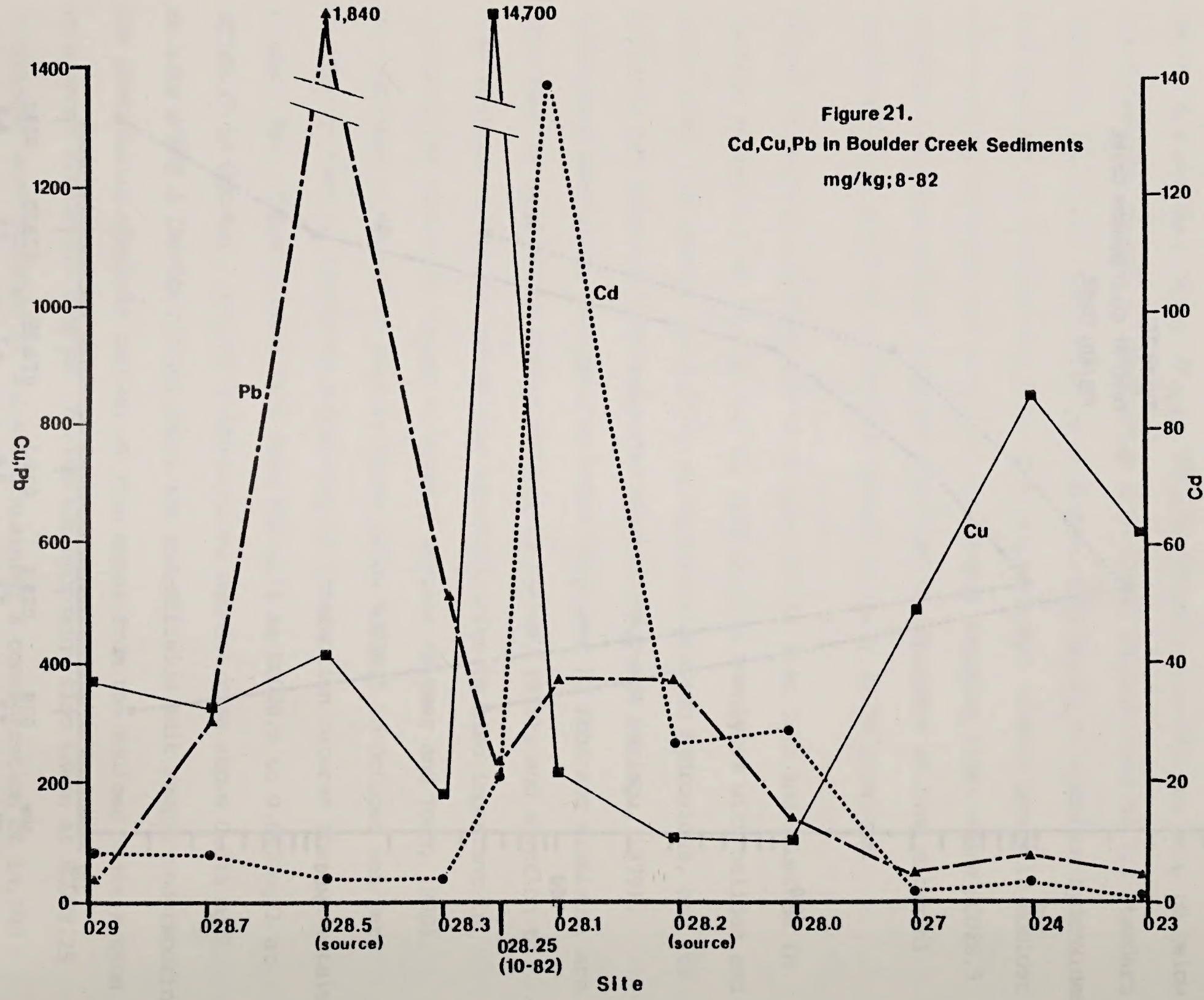


Figure 21.
Cd,Cu,Pb in Boulder Creek Sediments
mg/kg; 8-82

downstream distribution. A limiting mechanism similar to this has been documented in the coprecipitation of copper with manganese oxide complexes (Rubin, 1974).

Manganese and zinc are the most mobile of the common metals in aerated aqueous systems, and elevated concentrations of both metals, emanating from the BC028.5 seep, were encountered regularly at BC028.1, approximately one mile downstream of the seep (Figure 22). Hydrolysis and sorption to sediments are the primary factors limiting the distribution of these metals, but these processes generally do not become important until neutrality is reached. Manganese and zinc levels decreased relatively slowly downstream of BC028.5.

Zinc levels decreased from 41.9 mg/l in the seep to 1.7 mg/l above the mid-Hillside adit (BC028.1) in October; manganese concentrations decreased from 48.5 mg/l to 4.4 mg/l over the same stretch. The deposition patterns for the two metals were similar in that their highest sediment concentrations appeared approximately one mile below their source at BC028.5 (Figure 23). The concentrations of zinc remaining in water at site BC028.1 may have been biologically meaningful, in some cases exceeding the American Fisheries Society criterion for total zinc (AFS, 1979).

Cadmium's aqueous chemistry resembles that of zinc in many respects. Most cadmium salts are soluble at acidic or neutral pH, and sorption is the primary limiting mechanism on its dispersal in aquatic systems (USEPA, 1980c; Aylett, 1979). Cadmium is a toxic metal with demonstrated propensities toward biomagnification, making its mobility definite cause for concern. Though not as common as the aforementioned metals, cadmium was present at the BC028.5 seep at concentrations up to 0.029 mg/l, and in Boulder Creek immediately below the seep (BC028.3) at concentrations up to 0.037 mg/l. Attenuation of

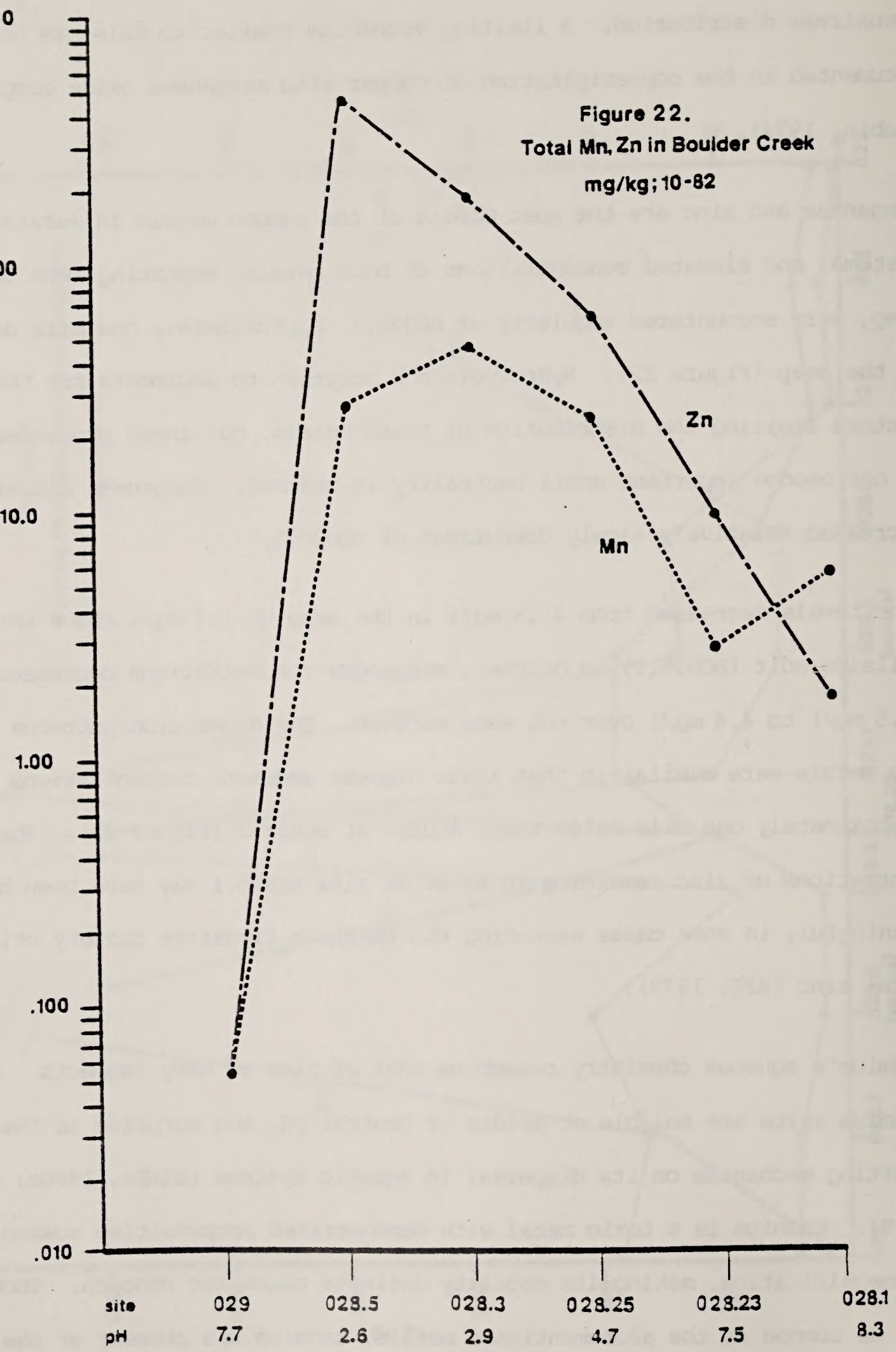


Figure 22.
Total Mn, Zn in Boulder Creek
mg/kg; 10-82

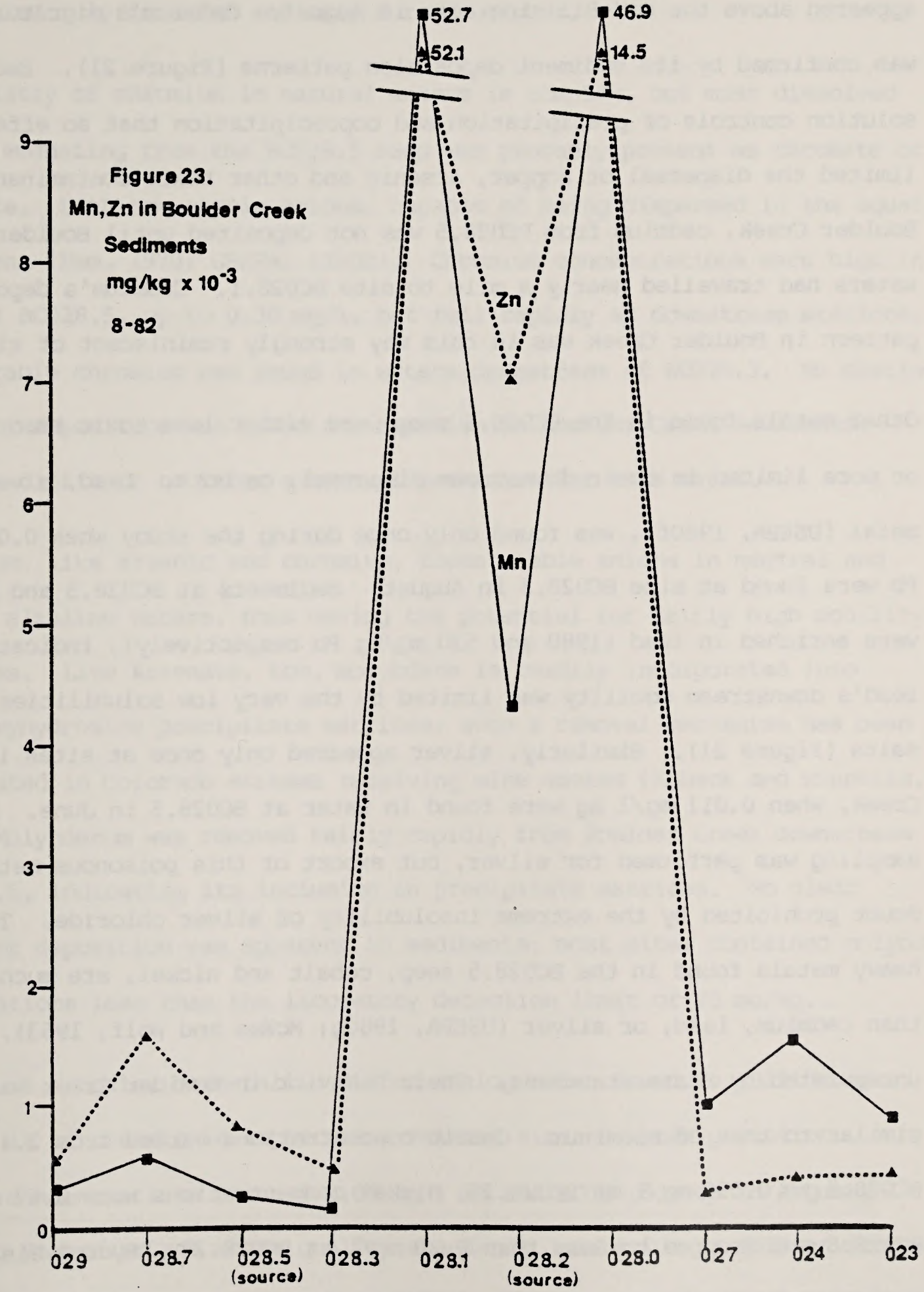


Figure 23.
Mn, Zn in Boulder Creek Sediments
mg/kg x 10^{-3}
8-82

cadmium in Boulder Creek during periods of low flow was slow; 0.012 mg/l Cd appeared above the mid-Hillside adit in August. Cadmium's migratory potential was confirmed by its sediment deposition patterns (Figure 21). Escaping the solution controls of precipitation and coprecipitation that so effectively limited the dispersal of copper, arsenic and other toxic contaminants in Boulder Creek, cadmium from BC028.5 was not deposited until Boulder Creek's waters had travelled nearly a mile to site BC028.1. Cadmium's deposition pattern in Boulder Creek was in this way strongly reminiscent of zinc's.

Other metals found in the BC028.5 seep were either less toxic than cadmium, or more limited in their downstream dispersal, or both. Lead, a very toxic metal (USEPA, 1980f), was found only once during the study when 0.014 mg/l Pb were found at site BC028.3 in August. Sediments at BC028.5 and BC028.3 were enriched in lead (1980 and 530 mg/kg Pb respectively), indicating that lead's downstream mobility was limited by the very low solubilities of its salts (Figure 21). Similarly, silver appeared only once at sites in Boulder Creek, when 0.011 mg/l Ag were found in water at BC028.5 in June. No sediment sampling was performed for silver, but export of this poisonous metal was no doubt prohibited by the extreme insolubility of silver chloride. Two other heavy metals found in the BC028.5 seep, cobalt and nickel, are much less toxic than cadmium, lead, or silver (USEPA, 1980g; McKee and Wolf, 1963), and are unregulated by State standards. Their behavior in Boulder Creek was generally similar to that of aluminum. Cobalt concentrations varied from 2.4 mg/l at BC028.5 to 0.090 mg/l at BC028.23; nickel concentrations were 0.63 mg/l at BC028.5 and dropped to less than 0.30 mg/l at BC028.25. Hydrolysis reactions, analogous to those engaged in by iron and aluminum, were probably important in limiting downstream concentrations of these two metals. Incorporation into metallic precipitates such as MnO, has been shown to restrict cobalt's

mobility at the pH's found in this system (Rubin, 1974). Nickel and cobalt were sampled only in water and only during October.

The chemistry of chromium in natural waters is complex, but most dissolved chromium emanating from the BC028.5 seep was probably present as chromate or dichromate. Both are stable anions, capable of being dispersed in the aquatic environment (Hem, 1970; USEPA, 1980d). Chromium concentrations were high in waters at BC028.5, up to 0.30 mg/l, but fell rapidly at downstream stations. No measurable chromium was found in waters downstream of BC028.3. No distinct pattern of deposition was noted for chromium in Boulder Creek sediments, making it difficult to infer a removal mechanism for this metal.

Molybdenum, like arsenic and chromium, forms stable anions in neutral and slightly alkaline waters, thus having the potential for fairly high mobility in streams. Like arsenate, too, molybdate is readily incorporated into ferric oxyhydroxide precipitate matrices; such a removal mechanism has been demonstrated in Colorado streams receiving mine wastes (Kaback and Runnells, 1980). Molybdenum was removed fairly rapidly from Boulder Creek downstream of BC028.5, indicating its inclusion in precipitate matrices. No clear pattern of deposition was apparent in sediments; most sites contained molybdenum concentrations less than the laboratory detection limit of 25 mg/kg.

Selenium is a toxic, nonmetallic sulfur analog often found in sulfide ores and thus is of concern in copper mine related air and water pollution. Selenium concentrations reached 0.06 mg/l in the BC028.5 seep in August, exceeding State surface water quality standards. Selenium in this environment was likely present as selenate (Hem, 1970), which is readily precipitated by ferric iron in the face of pH increases. This chemical mechanism limited selenium's spread in Boulder Creek, and measurable quantities of the element

were found only once at sites downstream of BC028.5. Selenium enrichment of sediments was observed in August at BC028.5, but other, anomalous occurrences of selenium in sediments, such as at BC029, were also noted.

Sulfate was the dominant anion in BC028.5 water, and Boulder Creek waters were greatly enriched in sulfate as a result of this input (Figure 24). Levels of sulfate in Boulder Creek downstream of the seep were far in excess of recommended drinking water limits (USPHS, 1962), although heavy metals levels at these sites were so high as to make sulfate a constituent of secondary concern. While sulfate enrichment was evident at all sites below BC028.5, considerable downstream attenuation of sulfate concentrations took place. Sediment data indicate that precipitation of sulfate with metals, principally iron, was the likely sulfate removal mechanism (Figure 25). All sediments downstream of BC028.5 were high in sulfate relative to upstream samples. Sulfate deposition was particularly evident in sediments at BC028.5, corresponding with iron deposition there, and at BC028.3, which may correspond with aluminum precipitation.

The influence of the BC028.5 seep on downstream water chemistry varied on a seasonal basis in response to the flow characteristics of Boulder Creek, which in turn were highly dependent on atmospheric precipitation. Water chemistry characteristics at BC028.3, a pool station 50 yards downstream of BC028.5 which received both seep and creek waters, changed drastically over the course of the study. During winter, spring, and early summer, Boulder Creek flow kept the water quality at BC028.3 reasonably high. No water quality violations were observed. During August and October, however, flow from tailings seepage dominated in BC028.3, resulting in a substantial reduction in water quality (Figure 26). Violations of State surface water quality

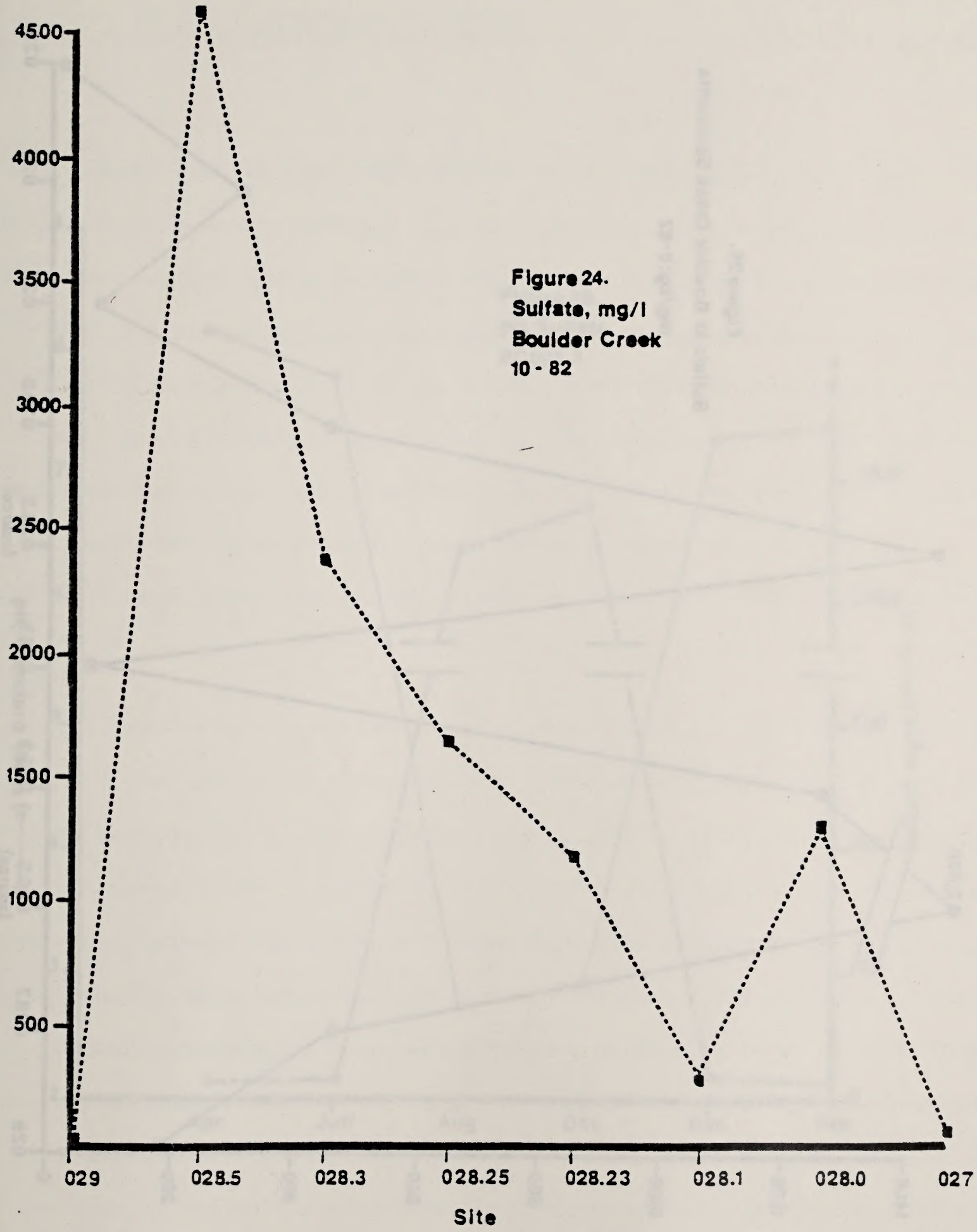


Figure 24.
Sulfate, mg/l
Boulder Creek
10 - 82

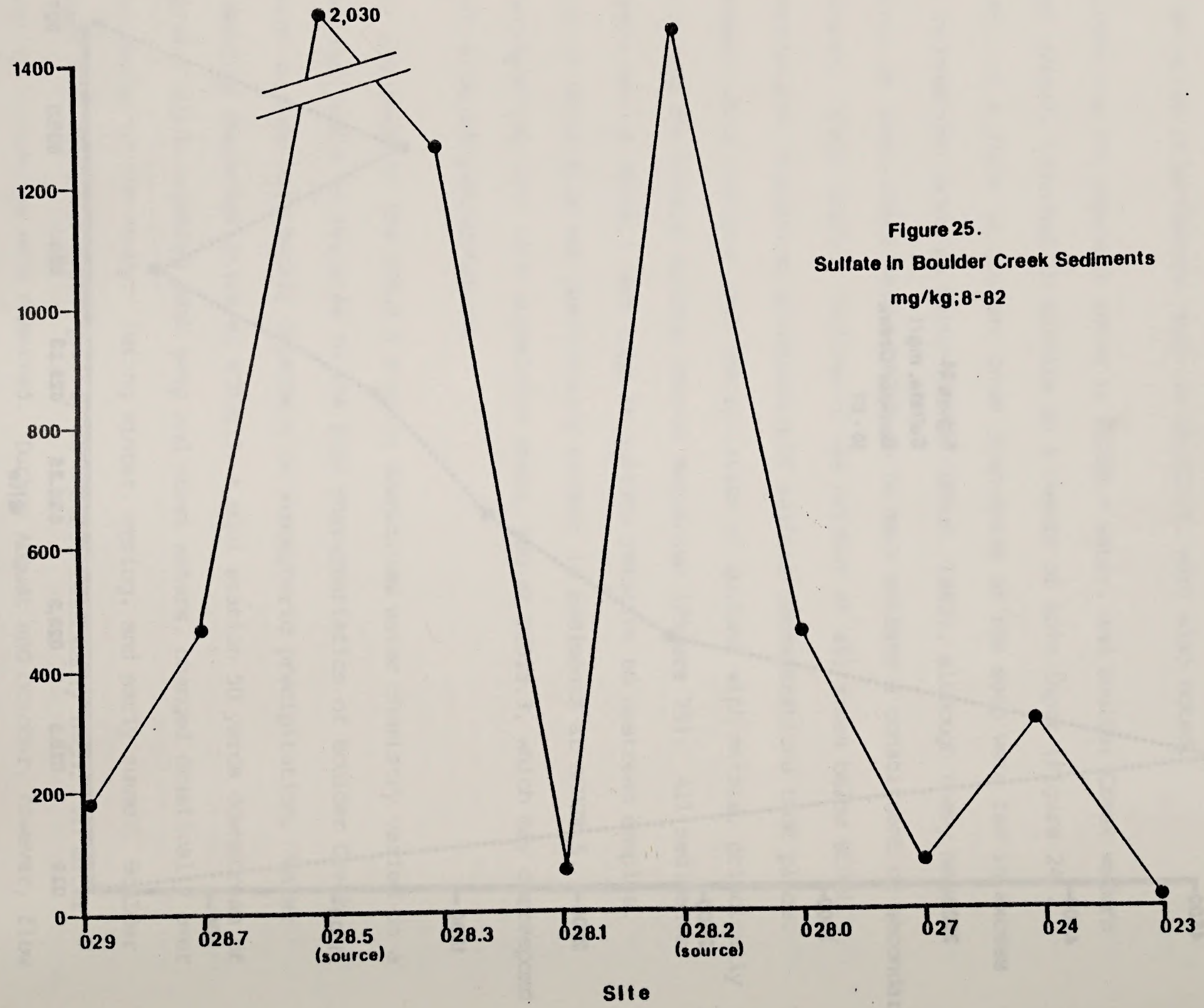


Figure 25.
Sulfate in Boulder Creek Sediments
mg/kg; 8-82

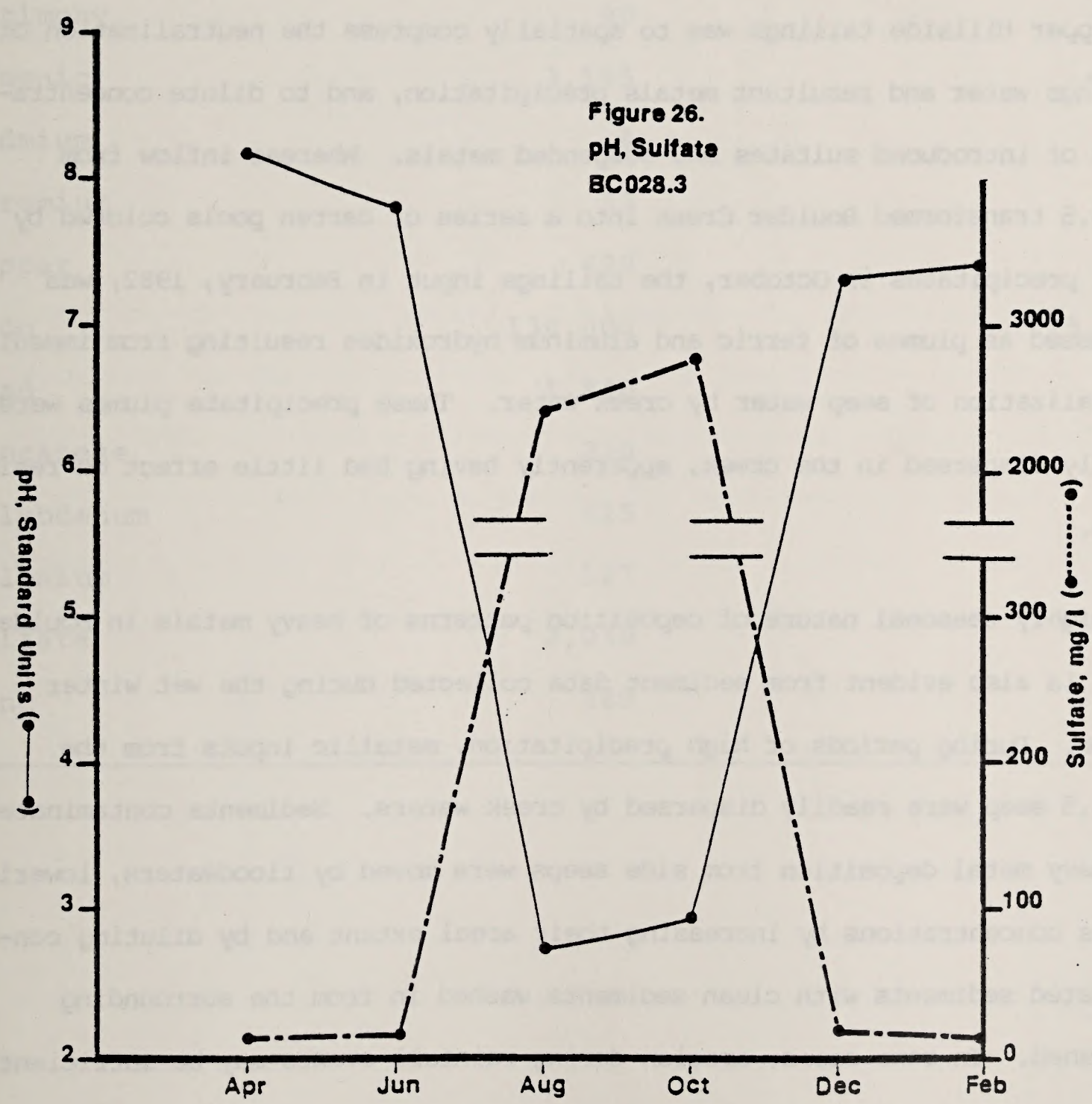


Figure 26.
pH, Sulfate
BC028.3

standards for pH, copper, zinc, arsenic, cadmium, and manganese occurred in the pool during these months, and the adverse effects of tailings seepage on instream water quality were noted downstream as far as site BC028.1, located nearly a mile from BC028.5.

The effect of uncontaminated inflow from Boulder Creek on the seepage from the upper Hillside tailings was to spatially compress the neutralization of tailings water and resultant metals precipitation, and to dilute concentrations of introduced sulfates and suspended metals. Whereas inflow from BC028.5 transformed Boulder Creek into a series of barren pools colored by metal precipitates in October, the tailings input in February, 1982, was expressed as plumes of ferric and aluminum hydroxides resulting from immediate neutralization of seep water by creek water. These precipitate plumes were quickly dispersed in the creek, apparently having had little effect on resident biota.

The highly seasonal nature of deposition patterns of heavy metals in Boulder Creek is also evident from sediment data collected during the wet winter season. During periods of high precipitation, metallic inputs from the BC028.5 seep were readily dispersed by creek waters. Sediments contaminated by heavy metal deposition from side seeps were moved by floodwaters, lowering metals concentrations by increasing their areal extent and by diluting contaminated sediments with clean sediments washed in from the surrounding watershed. In some cases, erosion during rainfall events may be sufficient to bury contaminated sediments. This took place in January, 1983, when sediments at BC028.5 were overlain by several inches of alluvial sand and gravel (Table 11). The result of atmospheric precipitation and runoff in Boulder Creek was nearly uniform sediment composition, except at sites very

Table 11. Concentrations of metals and sulfate in surficial sediments at site BCO28.5 in August 1982 and February 1983. All quantities mg/kg.

	Month	
Parameter	August	February
Antimony	90	<50
Arsenic	3,195	<150
Cadmium	4	<1
Chromium	37	9.5
Copper	420	48
Iron	130,000	15,145
Lead	1,840	<25
Manganese	220	489
Molybdenum	<25	<25
Selenium	127	<25
Sulfate	2,030	23
Zinc	880	152

near pollutant sources (Figure 27).

A more extreme example of acid mine drainage chemistry in the Boulder Creek watershed was afforded by a semi-permanent step (site BC100) which appeared as a bathtub-sized pool in a road on the upstream tailings, and had no direct connection to Boulder Creek. Metals levels in this seep were one to two orders of magnitude higher than in BC028.5 (Table 10), including very high concentrations of arsenic (163.4 mg/l) and antimony (99.7 mg/l). Lead, which was rarely found downstream of the BC028.5 seep, appeared at 0.27 mg/l, a value far in excess of State standards.

High concentrations of radionuclides and ionizing radiation were present in water at BC100. Gross alpha, gross beta, total radium -226 and total radium -228 levels exceeded State surface water quality standards. Total uranium, unregulated by State standards, was present at nearly 4 mg/l (Table 10). The presence of uranium in the upper Hillside tailings has been previously documented (Runnells, 1981), and interest has been expressed in mining the tailings to recover uranium. Measurements of radionuclides in Boulder Creek adjacent to the Hillside tailings were taken in February, 1983, during a period of high creek flow. No indication was given at that time that the Hillside tailings posed a radioactive contaminant danger to Boulder Creek. During low summer flow, however, when seeps from the Hillside complex became more important in determining ambient creek chemistry, radionuclide levels in Boulder Creek may increase to levels that would contravene State standards or pose a hazard to the downstream ecosystem. Further sampling seems justified to confirm or deny the existence of radionuclide contamination in Boulder Creek water and sediments.

The second major source of mine contaminants in the Hillside complex was a

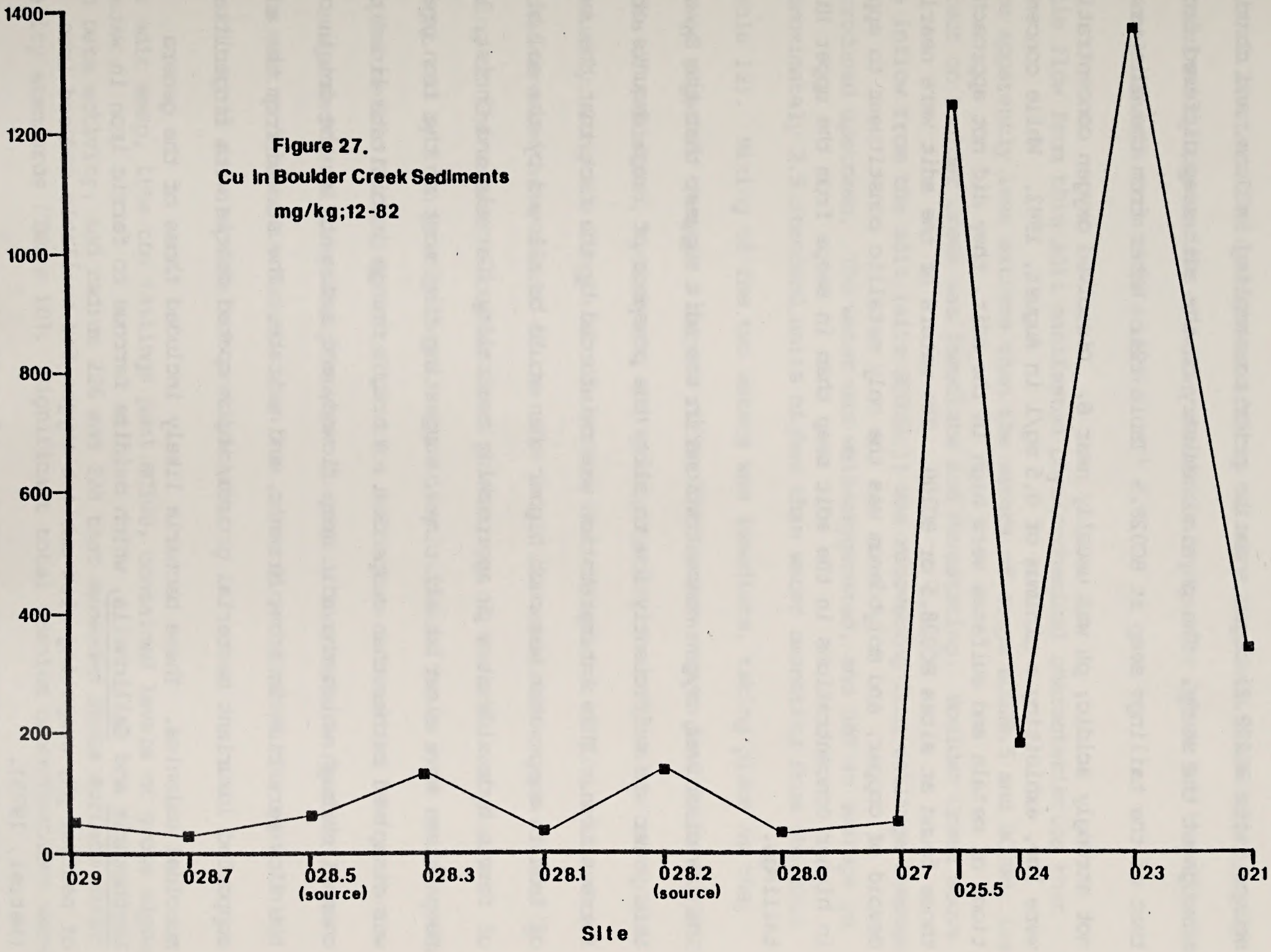


Figure 27.
Cu in Boulder Creek Sediments
mg/kg;12-82

seep emanating from a collapsed adit at the mine itself. Flow from this source (site BC028.2) began sometime prior to sampling in June, and continued throughout the study. The physicochemistry of the adit seep differed from that of the tailings seep at BC028.5 (Table 10). Water from the adit was not strongly acidic; pH was usually near 6. Dissolved oxygen concentrations were low, exhibiting a minimum of 0.5 mg/l in August, 1982. While concentrations of metals and sulfates were high in the adit, they did not approach those found at sites BC028.5 or BC100. The waters of the adit were nearly devoid of copper, and molybdenum was the only metallic constituent to appear in higher concentrations in the adit seep than in seeps from the upper Hillside tailings.

The low dissolved oxygen concentrations in the adit suggest that the E_h of this water was sufficiently low to allow the presence of large amounts of ferrous iron. This interpretation was reinforced by the fact that the amount of iron in seep water was much higher than would be allowed by the solubility of ferric hydroxide at a pH approaching neutrality (Garrels and Christ, 1964). Seep waters were clear at all times, suggesting that most of the iron present was dissolved rather than suspended. A bright orange precipitate lined the channel through which the adit seep flowed, and sediments at the origin of the flow were rich in iron, arsenic, and sulfate. The stream from the adit supported luxuriant bacterial growth, which coated debris with fingerlike, mucoidal colonies. These bacteria likely included those of the genera Lepthothrix and Gallionella, which oxidize ferrous to ferric iron in waters of neutral pH, competing with ambient oxygen for available reduced iron (Wetzel, 1975).

The physicochemistry of water from the adit did not vary seasonally to any

great degree. Flow likewise appeared to be fairly constant, and was estimated to be 0.25 cfs. The downstream effects of adit flow were therefore largely determined by the amount of water available in Boulder Creek for the dilution of contaminants from this source.

While flow from this adit manifested physicochemical characteristics that were apparently less extreme than the waters of seeps BC028.5 and BC100, its effect on Boulder Creek was immediate and devastating. Boulder Creek above the inflow from the adit (site BC028.1) was recovering from tailings seepage introduced upstream. The water was well-oxygenated, and had an average pH approximately 2.5 standard units higher than water emanating from the adit (Table 12). Mixing of the two waters was immediate, taking place as they flowed together through a narrow riffle into a downstream pool (site BC028.0). Rates of oxidation, hydrolysis, and precipitation of iron, which took place gradually along the length of the stream that flowed out of the adit, were much increased as a result of the rise in pH and available oxygen caused by mixing of the waters. Boulder Creek downstream of the adit was stained bright red by iron precipitates. Turbidity increased to as much as 1200 NTU (Nephelometric Turbidity Units) at site BC028.0 as a result of the presence of suspended metallic preicipitates. Turbidity increases in Boulder Creek were most prominent in summer, when low creek flow lessened the opportunity for dilution and dispersal of precipitates.

The adit seep, like the tailings pool BC100, contained levels of gross alpha and beta activity, and radium 226 and 228 that exceeded State surface water quality standards (Table 10). Significant total uranium concentrations were also found in seep waters (1.00 mg/l). While no downstream increases were noted for these parameters in Boulder Creek, samples were taken in February,

Table 12. Effects of Hillside adit seep (BC028.2) on Boulder Creek physicochemistry, 6-82. All quantities total mg/l, except where noted.

Parameter	Site	
	BC028.1 (above adit inflow)	BC028.0 (below adit inflow)
pH (standard units)	8.4	7.3
Oxygen, dissolved	9.8	6.8
Turbidity (NTU)	3	1,200
Total suspended solids	3	14
SO_4	39	485
As	0.03	1.20
Fe	< 0.1	11.5
Mn	0.37	18.7
Zn	0.28	3.6

1983, when ample runoff was available for dilution. The possibility exists that the middle Hillside adit seep is a significant source for the radiological contamination of Boulder Creek in summer, when seep waters make up an important portion of downstream flow.

Associated with increases in suspended particles in Boulder Creek as a result of inflow from the Hillside Mine adit were increases in total iron, manganese, arsenic, and zinc (Table 12). Sulfate levels also increased. Sediments collected at BC028.0 were enriched in metals and sulfates, apparently due to the settling of precipitates whose constituents originated from the adit. A reduction in dissolved oxygen was noted in Boulder Creek downstream of the adit flow, consistent with the oxidation of ferrous iron as the two waters mixed. The most meaningful measured effect of the adit on instream water quality was, however, the introduction of high levels of suspended particles.

The lower Hillside tailings exerted a noticeable effect on Boulder Creek quality in October, when a single grab sample was taken below the furthest downstream extent of these tailings (site BC027.9). The water at this time was a murky aqua, and the bottom was covered with a grayish floc. Water chemistry was characterized by near-neutral pH (7.4), and high levels of sulfate (9649 mg/l), total manganese (23.2 mg/l), and total zinc (7.6 mg/l).

Boulder Creek near Butte Creek (downstream effects of the Hillside complex) --Boulder Creek was sampled in the vicinity of Butte Creek throughout the study to determine the effects of contaminant sources at the Hillside complex on downstream chemistry. The Butte Creek confluence is approximately 1.5 river miles downstream of the lowermost extent of the Hillside complex. During February and April, 1982, Boulder Creek was sampled below its confluence with Butte Creek (Butte Creek constituted 1.4% of downstream Boulder Creek

flow in April). Subsequently, Boulder Creek was sampled above its confluence with Butte Creek.

Boulder Creek near Butte Creek (site BC027) was chemically similar to its natural constituent waters, Wilder Creek and Boulder Creek above Wilder Creek (Table 13). The pH at BC027 was consistently alkaline, averaging 7.9 standard units. Dissolved oxygen levels at this site were usually at or near saturation, and did not exhibit a pronounced summertime depression in per cent saturation, as noted at Boulder Creek upstream of the Wilder Creek confluence. This may have been due to the fact that site BC027 usually exhibited some throughflow, and that pool volume at the site in summer was much larger than at the site sampled above Wilder Creek.

Sodium and bicarbonate were the dominant ions in Boulder Creek near Butte Creek, as they were in Wilder Creek and in Boulder Creek above Wilder. Average concentrations of the two ions were comparable at all three sites. Sulfate levels were approximately four times higher at BC027 than at BC029 or BC060, probably resulting from sulfate input at the Hillside complex. The divalent cations calcium and magnesium, mobilized by acid mine drainage, were elevated in Boulder Creek near Butte Creek, as was potassium. Analyses of variance showed that downstream increases in concentrations of sulfate, calcium, magnesium, and potassium at BC027 (compared to BC029 and BC060) were significant, in spite of wide seasonal fluctuations in their concentrations at all three sites. Total dissolved solids levels at BC027 showed the same type of seasonal variation as at BC029, although the discrepancy between summer and winter TDS levels was not as great at the downstream site.

Heavy metals were present in Boulder Creek waters near Butte Creek on a more consistent basis than at sites upstream of the Hillside complex, although no

Table 13. Physicochemistry of Boulder Creek intensive survey sites near Butte Creek (BC027) and below Copper Creek (BC024). All quantities mg/l except where indicated.

Parameter	Site* BC027 mean	BC027 max	BC027 min	BC024 mean	BC024 max	BC024 min
H_2O temperature (^oC)	16	28	8	15	27	6
pH (standard units)	7.9	8.3	7.4	7.6	8.2	7.2
Oxygen, dissolved	10.3	12.8	7.9	10.3	13.6	6.8
TDS, residue	260	440	116	1,020	2,408	96
Total suspended solids	6	15	< 1	11	49	1
Alkalinity, $CaCO_3$	117	200	30	102	163	27
Na	43	94	9	11	155	< 10
Ca	29	44	11	143	336	11
Mg	11	21	4	60	139	2
K	4	7	2	7	15	2
Cl	14	29	2	37	83	1
SO_4	48	97	15	536	1,407	19
F	1.91	3.44	0.82	1.87	3.11	0.43
NO_3-N	< 0.05	0.09	0.01	< 0.11	0.17	< 0.04
Kjeldahl N	< 0.66	1.50	< 0.20	< 0.59	1.30	< 0.10
Total PO_4-P	< 0.05	0.06	< 0.05	< 0.05	0.05	< 0.05
As, dissolved	<0.026	0.039	<0.020	<0.022	0.030	<0.020
As, total	<0.022	0.038	<0.020	<0.024	0.040	<0.020
Cu, dissolved	ND	ND	ND	<0.010	0.016	<0.010
Cu, total	<0.028	0.017	<0.010	<0.010	0.030	<0.010
Fe, dissolved	<0.162	0.420	<0.100	<0.150	0.420	<0.050
Fe, total	<0.561	1.980	0.060	<0.884	4.550	<0.050
Mn, dissolved	<0.092	0.290	<0.050	<0.075	0.250	<0.050
Mn, total	<0.147	0.340	<0.050	<0.150	0.350	<0.050
Mo, dissolved	<0.021	0.040	<0.010	<0.015	0.029	<0.010
Mo, total	<0.019	0.040	<0.010	<0.014	0.025	<0.010
Zn, dissolved	<0.050	0.050	<0.050	<0.050	0.090	<0.050
Zn, total	<0.132	0.400	<0.050	<0.050	0.080	<0.050
Fecal coliforms (cfu/100 ml)	5	11	< 2	39	130	< 2

ND - not detected

* - sample size for both sites = 7

State surface water quality standards were violated (Table 13). Dissolved and total arsenic, iron, manganese, and zinc were all found more frequently in water at BC027 than at BC029 or BC060. It is unclear in some cases, however, exactly what portion of this apparent increase in metals is attributable to input from the Hillside, especially since the degree of hydrologic connection between site BC027 and metals sources at the Hillside during periods of low water is unknown, and the importance of various transport modes in the watershed during such periods can only be guessed at. For instance, although total manganese reached detectable levels at BC027 more frequently, summertime levels of total manganese at BC029 were higher, in spite of the lack of apparent sources for the metal at this latter point (Figure 28). Other factors, such as concentration by evaporation and biological mediation of manganese release from sediments may have been as important on a site-by-site basis as the presence of upstream sources in determining manganese levels in Boulder Creek waters. The presence of arsenic and zinc in water at BC027 may be more directly attributable to Hillside input. Both elements can be fairly mobile in stream waters (if arsenic concentrations are not limited by ferric hydroxide precipitation), and neither reached detectable concentrations in waters above the Hillside complex. Arsenic levels varied on a seasonal basis, rising above laboratory dectection limits in the June, August, and October sampling.

The effects of the Hillside complex on metal levels in sediments in Boulder Creek near Butte Creek were inconsistent, varying from metal to metal (Table 14). Often, downstream enrichment noted during one sampling period was absent at another. Manganese and iron were found at consistently higher concentrations at BC027 than at BC029, although neither of these constituents reached levels found in sediments closer to sources at the Hillside. Levels

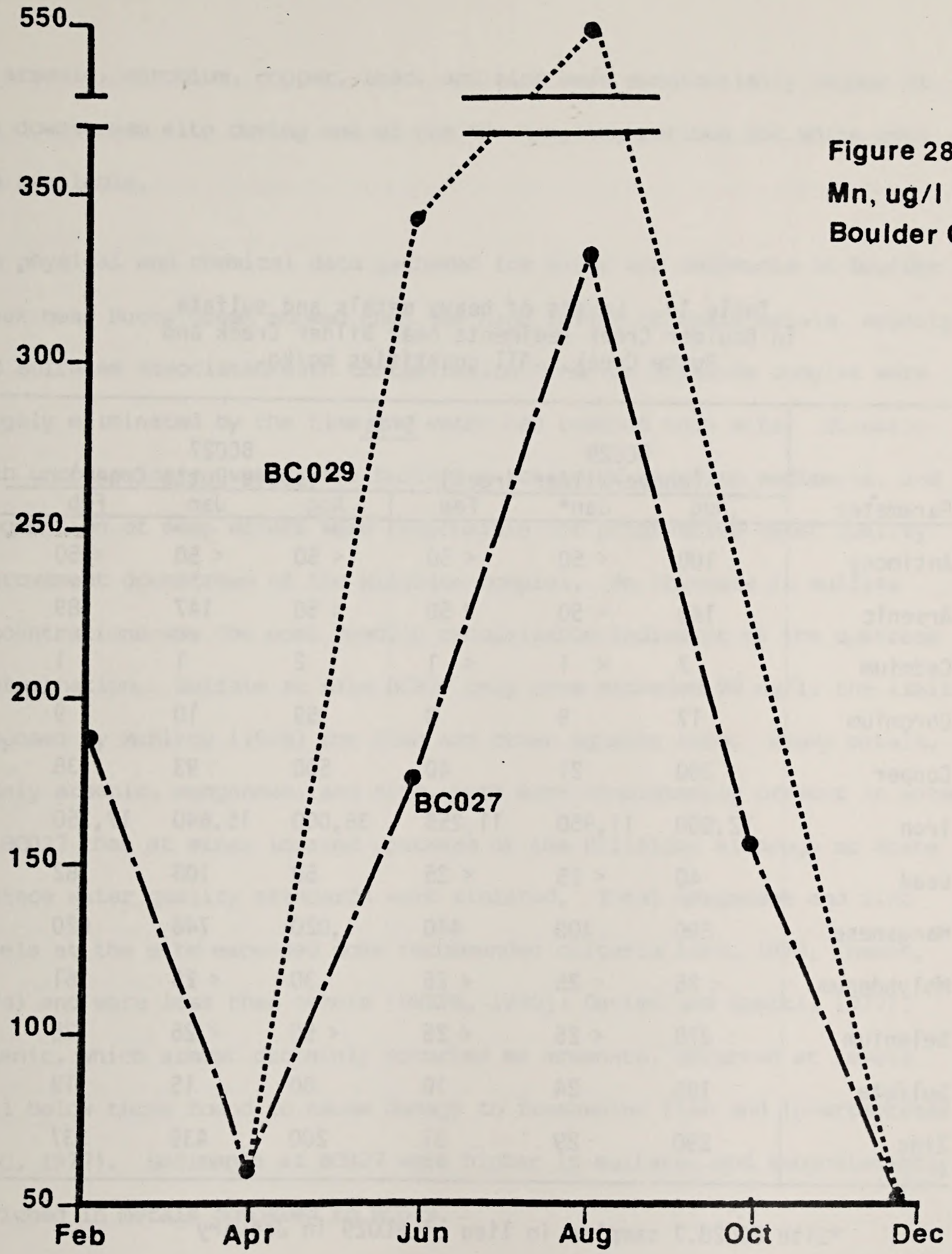


Figure 28.
Mn, ug/l
Boulder Creek

Table 14. Levels of heavy metals and sulfate in Boulder Creek sediments near Wilder Creek and Butte Creek. All quantities mg/kg.

Parameter	Site: BC029 (above Wilder Creek) Aug	Jan*	Feb	BC027 (above Butte Creek) Aug	Jan	Feb
Antimony	100	< 50	< 50	< 50	< 50	< 50
Arsenic	140	< 50	< 50	< 50	147	89
Cadmium	7	< 1	< 1	2	1	1
Chromium	17	9	8	59	10	9
Copper	390	21	40	500	93	38
Iron	12,000	11,950	11,255	38,000	15,640	17,350
Lead	40	< 25	< 25	50	108	82
Manganese	290	400	440	1,020	748	620
Molybdenum	< 25	< 25	< 25	30	< 25	61
Selenium	278	< 25	< 25	< 50	< 25	25
Sulfate	185	24	10	80	15	18
Zinc	290	29	31	200	439	337

*Site BC028.7 sampled in lieu of BC029 in January

of arsenic, chromium, copper, lead, and zinc were substantially higher at the downstream site during one of the two sampling periods for which data are available.

The physical and chemical data gathered for water and sediments at Boulder Creek near Butte Creek showed that the high levels of toxic metals, acidity, and sulfates associated with contamination from the Hillside complex were largely eliminated by the time the water had reached this site. Dilution with uncontaminated water, the buffering action of riverine sediments, and oxygenation of seep waters were responsible for progressive water quality improvement downstream of the Hillside complex. An increase in sulfate concentrations was the most readily recognizable indicator of the upstream contamination. Sulfate at site BC027 only once exceeded 90 mg/l, the limit proposed by McKirdy (1968) for fish and other aquatic life. Heavy metals, namely arsenic, manganese, and zinc, were more consistently present in water at BC027 than at sites located upstream of the Hillside, although no State surface water quality standards were violated. Total manganese and zinc levels at the site exceeded some recommended criteria (AFS, 1979; Dawson, 1974) and were less than others (USEPA, 1980j; Davies and Goettl, 1977). Arsenic, which almost certainly occurred as arsenate, occurred at levels well below those found to cause damage to freshwater fish and invertebrates (NRC, 1977). Sediments at BC027 were higher in sulfate, and inconsistently enriched in metals compared to BC029.

Thus, Boulder Creek in the vicinity of the Butte Creek confluence is a stream affected by, though perhaps not afflicted by, contamination from the Hillside mine complex. The ability of this study to resolve upstream-downstream differences in metals levels due to the Hillside input is limited, as are

all such studies, by laboratory detection limits. It is possible though, that the available detection limits were adequate to discover biologically meaningful changes in quantities of heavy metals in water and sediments.

Nutrient behavior at BC027 was apparently unaffected by contamination from the Hillside complex. Kjeldahl nitrogen was the only nitrogen form detected at this site, and ranged from less than 0.1 to 1.5 mg/l as N. No trends attributable to seasonal climatic variations were discernible. Total and orthophosphate phosphorus concentrations were higher here than at sites above the Hillside, which was somewhat surprising since ferric iron precipitation usually strictly limits aqueous phosphate levels (Stumm and Morgan, 1981; Lampkin, 1980). Total phosphorus levels ranged from less than 0.05 to 0.07 mg/l; orthophosphorus concentrations ranged from less than 0.01 to 0.04 mg/l. No seasonal trends in phosphorus levels were evident. As with other sites in the drainage, nitrogen was abundant relative to phosphorus, suggesting that phosphorus would be the nutrient most likely to limit plant growth.

Fecal coliform bacterial populations peaked at 11 colony forming units/100 ml, a level far below applicable State surface water quality standards. Populations were consistently low in spite of obvious use of the creek at this point by wildlife, whose tracks were often noted here by field personnel.

D. Boulder Creek--Above Copper Creek Confluence to Mouth: This subsection includes data from four stations: BC041, Copper Creek near its mouth; BC042, a Cyprus-Bagdad monitor well in the Copper Creek alluvial fan; BC045, a drill hole in Cyprus-Bagdad's east pit; and BC025.5, Black Mesa Gulch just above its confluence with Boulder Creek. The Copper Creek drainage, including apparently, Black Mesa Gulch, has historically been the source of destructive loadings of acids, metals, and sulfate emanating from Cyprus-Bagdad's then-poorly contained

sulfuric acid heap leach copper recovery operation (Kepner, 1980; Rampe, 1982a). The heap leach remains near the mouth of Copper Creek. Cyprus-Bagdad, however, has constructed improvements in the form of a more efficient leachate recovery system, and a downstream catchment basin and pump-back system to retain flood runoff. Cyprus-Bagdad spent approximately $1,000,000 on these improvements. Surface and shallow groundwater still enters Boulder Creek from Copper Creek and Black Mesa Gulch. This subsection will examine the chemistries and sources of these influent waters, and their effect on downstream water quality in Boulder Creek.

Surface and Subsurface Flow in Copper Creek--Surface flow near the mouth of Copper Creek (site BC041) was sampled from a ditch approximately 100 feet upstream of Boulder Creek. Flow was present at all sampling times, emanating from a pipe which drained water from Cyprus-Bagdad's catchment basin directly upstream, which was under construction at the time of the study. Springs in the Copper Creek canyon may have been the ultimate source for this water. Shallow groundwater was sampled from a monitor well (site BC042) located adjacent to the ditch. This well was approximately 75' deep, drawing water from the Copper Creek alluvium. The well was designed to monitor underflow and seepage from the upstream catchment facility. The amount of alluvial underflow apparently varied seasonally, as reflected by the fact that continuous pumping from the monitor well in late summer produced intermittent flow and turbid water.

Water from both sources contained high concentrations of TDS and sulfates (Table 15), both of which regularly exceeded recommended drinking water limits (USPHS, 1962; NRC, 1977). Sulfates also exceeded suggested aquatic life limits (McKirdy, 1968). TDS and sulfate concentrations in both waters varied

Table 15. Physicochemistry of surface and shallow groundwaters in Copper Creek and Black Mesa Gulch. All quantities total mg/l except where noted.

Parameter	Site: Copper Creek ditch BC041			Copper Creek well BC042			Black Mesa Gulch BC025.5		
	mean	max	min	mean	max	min	mean	max	min
pH (standard units)	7.8	8.2	7.4	7.0	7.3	6.9	7.9	8.2	7.8
Oxygen, dissolved	9.7	11.4	8.1	3.8	6.9	1.6	11.8	12.4	10.8
Alkalinity, $CaCO_3$	85	96	75	167	179	149	142	194	85
TDS, residue	2,397	2,620	2,180	1,764	1,993	1,567	1,865	2,348	1,047
Na	110	125	94	175	198	154	73	90	45
Ca	382	424	345	243	296	208	309	368	190
Mg	128	161	113	80	96	67	104	146	45
K	15	28	12	22	26	20	6	7	6
Cl	55	59	52	60	62	55	53	62	37
SO_4	1,487	1,703	1,356	977	1,143	868	1,081	1,368	552
F	3.00	3.84	2.62	3.12	3.55	2.67	1.39	1.48	1.30
NO_3-N	0.84	2.96	0.22	0.88	1.30	0.09	2.80	3.40	2.27
As, total	ND	ND	ND	0.890	4.310	0.030	ND	ND	ND
As, dissolved	<0.040	0.160	<0.020	0.079	0.141	0.020	NA	NA	NA
Cd, total	<0.007	0.014	<0.005	<0.005	0.006	<0.005	ND	ND	ND
Cd, dissolved	<0.005	0.007	<0.005	ND	ND	ND	NA	NA	NA
Cr, total	<0.021	0.010	<0.010	<0.017	0.050	<0.010	ND	ND	ND
Cu, total	<0.266	0.740	0.040	<0.946	4,800	<0.050	<0.022	0.030	<0.010
Cu, dissolved	<0.291	0.990	0.022	<0.025	0.020	<0.010	NA	NA	NA
Fe, total	< 0.69	2.01	< 0.10	<24.50	124.00	< 0.05	0.15	0.20	0.11
Fe, dissolved	< 0.08	0.05	< 0.05	< 0.61	1.51	< 0.05	NA	NA	NA
Mn, total	0.59	0.95	0.44	0.20	0.39	0.05	0.12	0.18	0.08
Mn, dissolved	0.55	0.88	0.43	< 0.15	0.28	< 0.05	NA	NA	NA
Mo, total	<0.026	0.077	<0.010	0.047	0.068	0.020	<0.020	0.040	<0.010
Mo, dissolved	<0.022	0.040	<0.010	0.037	0.063	0.020	NA	NA	NA
Sb, total	<0.013	0.020	<0.010	<0.017	0.030	<0.010	ND	ND	ND
Sb, dissolved	<0.012	0.020	<0.010	<0.014	0.030	<0.010	NA	NA	NA
Zn, total	< 0.26	0.65	< 0.05	< 1.56	8.40	< 0.05	ND	ND	ND
Zn, dissolved	ND	ND	ND	< 3.03	17.30	< 0.05	NA	NA	NA

ND - not detected; NA - not analyzed

only slightly during the study and were not responsive to seasonal changes in the manner displayed by upstream surface waters in Boulder Creek. TDS and sulfate concentrations were consistently higher in surface samples than in monitor well samples.

Calcium was the dominant cation in both waters. Both waters also contained large amounts of sodium and magnesium. Sodium was more abundant in ground water than in surface water at these sites; the opposite was true of magnesium. These waters were distinguished by their very high levels of potassium, up to 27.8 mg/l, the highest potassium levels found at any site during the study.

Surface water at the mouth of Copper Creek was continually well-oxygenated. Oxygen saturation reached 119% in October, probably the result of growths of filamentous green algae in the water. The pH was slightly alkaline, ranging from 7.4 to 8.2 standard units. Alluvial water sampled from the monitor well, by contrast, was deficient in dissolved oxygen. The highest oxygen concentration observed was 6.9 mg/l; other observations ranged between 1.6 and 4.9 mg/l. These measurements were doubtless higher than ambient aquifer concentrations of oxygen due to the mixing of these samples with atmospheric oxygen. The pH of this shallow groundwater was also depressed, ranging from 6.9 to 7.3 standard units.

Manganese and zinc, two heavy metals which were relatively mobile in surface waters in Boulder Creek, were consistently present at potentially significant concentrations in Copper Creek surface waters. Total manganese concentrations reached 0.95 mg/l in April, approaching Dawson's suggested limit of 1 mg/l for protection of aquatic life (Dawson, 1974). Total zinc concentrations reached 0.65 mg/l in February, 1983, exceeding the American Fisheries Society's recommended freshwater limit for this element (AFS, 1979). Both of these

elements were present primarily in the dissolved state, increasing their potential significance as downstream contaminants. Dissolved zinc in Copper Creek surface waters exceeded the State surface water quality standard of 0.5 mg/l twice, during December and February, 1983. Dissolved copper concentrations reached or exceeded the State standard (0.05 mg/l) three times, in February and December, 1982, and during February, 1983. Suspended iron was present in some samples, but at low, probably insignificant levels. Two trace metals known to occur in the Copper Creek drainage, antimony and molybdenum, were found consistently in surface water there. The highest recorded antimony level was 0.02 mg/l, far below EPA's freshwater criteria of 0.610 mg/l for freshwater life and 0.146 mg/l for human health protection. Molybdenum, unregulated in surface waters by Arizona State water quality standards or EPA criteria, reached 0.077 mg/l in April, 1982.

Analysis of heavy metals data from the monitor well is somewhat confounded by the occasional presence of suspended sediments drawn when water levels in the shallow alluvial aquifer were probably at their lowest. Suspended solids levels in well water were often high, reaching 204 mg/l in February, 1983. Some anomalously high total metals values, such as those for iron (which reached 124 mg/l) may be explained by the presence of high sediment concentrations in samples although the well was pumped as thoroughly as possible prior to sampling to minimize such contamination. Certain trace elements appeared in well water in the dissolved state, however, and in amounts sufficient to cause concern regarding the quality of the alluvial aquifer in Copper Creek.

Foremost among these elements was arsenic. Dissolved arsenic in well samples reached 0.141 mg/l in October, and exceeded 0.1 mg/l during most of the second

half of the study. The presence of dissolved arsenic was closely linked to the presence of dissolved iron, which reached 1.5 mg/l, and low dissolved oxygen concentrations in alluvial water. These coincident conditions suggest that arsenic transport in alluvial Copper Creek water, along with downstream migration of arsenic in Boulder Creek, was governed by the same chemical process that limited arsenic export from the adit seep at the Hillside complex, namely the coprecipitation of arsenic with iron as ferric hydroxyarsenates. Free arsenic, as well as free iron, were both allowed to exist in these waters because oxygen tensions were low. Subsequent mixing of alluvial Copper Creek water with well-oxygenated, alkaline Boulder Creek surface waters strongly limited export of arsenic from this source. In fact, arsenic was not detected in most samples in Boulder Creek immediately downstream of the mouth of Copper Creek, and never exceeded the State surface water quality standard for protection of aquatic life of 0.05 mg/l. The continuing presence of arsenic in this well mandates that it not be used as a drinking water source, and it is recommended that Cyprus-Bagdad post a sign near the well to that effect.

Other metals were present in Copper Creek alluvial water samples in dissolved or suspended forms. Manganese was ubiquitous in these samples, but at levels that were generally lower than in Copper Creek surface waters. Zinc appeared as an important constituent during the latter half of the study, at the same time that arsenic levels increased. It is unclear whether the trend noted for these two elements represents a trend toward deterioration of the quality of this small aquifer, but continued sampling of the well seems warranted on the basis of these observations. Molybdenum and antimony were both found in well water, at levels comparable to those found in surface water. Total copper was found consistently in the well in the latter half of the study, following the pattern of zinc. Cadmium was present only once, when 0.006

mg/l total cadmium appeared in October.

To summarize, metals levels in Copper Creek waters sampled during the study were often low, but at times exceeded State standards or EPA, American Fisheries Society, or other suggested criteria for metallic constituents in freshwater. Arsenic levels in subterranean alluvial waters were high, but probably do not pose a significant danger to the downstream ecosystem given the physicochemical controls imposed by this system on arsenic solubility. Dissolved copper and zinc concentrations exceeded State standards in surface waters and dissolved zinc concentrations in well water also exceeded State standards. Continued monitoring for these parameters should be performed. Sulfate concentrations were also high in these waters and caused a pronounced elevation of sulfates in Boulder Creek, particularly during dry weather (see ensuing discussion regarding Boulder Creek). Sulfate, occurring in this case primarily as calcium sulfate, is a fairly innocuous ion as regards aquatic life, and its possibly excessive presence in Copper Creek waters is somewhat counterbalanced by the partial hydrologic dependence of Boulder Creek on Copper Creek waters for maintenance of summertime flow.

Collections of Copper Creek surface waters were made by the USGS, USEPA, and U.S. Fish and Wildlife Service in 1978, 1979, and 1980, a time when downstream aquatic communities were severely stressed as a result of inflow from the Copper Creek drainage (USGS, 1980; Kepner, 1980). A comparison of heavy metal results from these previous samplings with those obtained from the current intensive survey shows some water quality improvement, although water quality violations persist (Table 16). These figures belie the observed recovery of the aquatic ecosystem downstream of Copper Creek, however, a recovery that has taken place since the onset of Cyprus-Bagdad's watershed

Table 16. Maximum metals levels in Copper Creek surface waters 1979 and 1982. All quantities dissolved mg/l. USGS 1979 data from water quality monitoring station number 09424437 (USGS, 1980). 1982 data from intensive survey.

Metal	1979 Concentration	1982 Concentration
As	0.012	0.16
Cu	0.39	0.99
Fe	0.25	0.05
Mn	1.40	0.88
Se	0.011	< 0.005
Zn	0.19	< 0.05

improvements, and is certainly the direct result of such. The benefits realized by Cyprus-Bagdad's project have probably resulted not so much from water quality improvements in Copper Creek as from a sharp reduction in runoff of contaminated water from the drainage. Flow records maintained by USGS during water year 1979 showed the average surface discharge of Copper Creek to be 2.2 cfs, with a maximum dishcarge of 8.0 cfs in September, 1979. Alluvial discharge entering Boulder Creek from Copper Creek was not monitored, but was likely higher previous to the installment of a more sophisticated leachate collection system by Cyprus-Bagdad. Estimated surface flow in Copper Creek during the intensive survey did not exceed 0.5 cfs, and was constant throughout the survey. The improvements made in the Copper Creek drainage have apparently lessened the hydrologic dependence of Boulder Creek on flow from Copper Creek. This flow reduction in Copper Creek has been the primary benefit realized from Cyprus-Bagdad's efforts, and has in turn allowed stream recovery.

The question as to the exact source of high levels of sulfate, TDS, and metals observed in Copper Creek waters during the intensive survey has been rendered less urgent by the recovery staged by downstream communities in Boulder Creek. This study provided little direct evidence for the resolution of this question. Naturally occurring waters in the area have been documented with chemistries roughly similar to those exhibited by waters sampled from Copper Creek (Runnells, 1981), and much of the flow at BC041 may have originated from spring flow. Copper Creek waters nonetheless strongly resemble well-buffered mine runoff in terms of their high sulfate concentrations and levels of divalent cations and potassium. A single sample of artesian water was taken from a drill hole in Cyprus-Bagdad's east pit (BC045) in February, 1982. This water, taken above the heap leach pile, contained lower levels of calcium (39 mg/l)

than other Copper Creek waters and undetectable levels of copper and other heavy metals. These results demonstrate that the chemistries observed in samples taken from BC041 and BC042 do not occur universally in native waters from the Copper Creek drainage. At least one of Runnells' samples mentioned above was taken from a seep at the mouth of Copper Creek (dry during this study), located at a point where its chemistry could have been influenced by the leach operation. Cyprus-Bagdad's heap leach copper recovery operation near the mouth of Copper Creek still represents a massive potential source for waterborne sulfates, and possibly for heavy metals. It is the author's opinion that Cyprus-Bagdad's heap leach operation exerts a strong influence on the chemistry of Copper Creek waters entering Boulder Creek. While Cyprus-Bagdad's commendable efforts to reduce Copper Creek flow have been highly successful in allowing Boulder Creek's recovery, continued monitoring of the chemical quality of surface and groundwaters in Copper Creek is recommended in light of the existence of this source.

Black Mesa Gulch--Black Mesa Gulch is a steep, narrow, heavily vegetated ravine that joins Boulder Creek approximately 1/4 mile upstream of the Copper Creek confluence. Flow in the gulch was first discovered in October, 1982, when it comprised the entire surface flow in Boulder Creek at that point. The small stream originated from a spring at the base of a large overburden dump, overburden which may contain environmentally significant quantities of metal sulfide minerals. The stream appeared to be perennial, as it was discovered near the end of a dry summer. It was sampled at a single site near the creek's mouth (BC025.5) during the October, December, 1982 and February, 1983 sampling trips.

The physicochemical characteristics of the stream in Black Mesa Gulch were

very similar to those of the surface stream sampled near the mouth of Copper Creek (site BC041; Table 15). Levels of sulfate and TDS were nearly identical to those found in Copper Creek, although dilution occurred in the Black Mesa Gulch stream in February, 1983, in response to seasonal rains. Calcium was the most abundant cation, followed by appreciable concentrations of magnesium, sodium, and potassium.

Dissolved oxygen levels in the stream deviated little from 100% saturation, to be expected since equilibrium was maintained with the atmosphere by the waters tumbling down the steep slope of Boulder Creek Canyon, and since the shaded aspect of the creek precluded significant algal growth. The pH of the water was slightly alkaline, ranging from 7.8 to 8.0 standard units, well within the range of variation found in surface water in Copper Creek.

Nitrate nitrogen concentrations in the Black Mesa Gulch stream were the highest of any site in the study, surpassing those of warm springs sampled on Francis Creek. Nitrate nitrogen concentrations reached 3.4 mg/l in February, 1983. In this case, nitrate elevation may have been due in part to release of fixed nitrogen from leguminous shrubs (mesquites and acacias) which grew profusely in the gulch. Whatever the origin, the waters of Black Mesa Gulch and alluvial waters in Copper Creek represent significant nitrogen sources for downstream biota, in much the same way as the warm springs on Francis Creek.

Black Mesa Gulch contained consistently measurable levels of total iron, total manganese, and total copper. Concentrations of these metals in stream water did not violate State surface water quality standards, nor did they exceed EPA criteria for the protection of freshwater life. The amount of copper carried by the stream proved to be quite large when sediment data were

analyzed, however. Collections of brown silty clay made at the base of the Gulch in October, 1982 and February, 1983, contained more copper (up to 1950 mg/kg) than any other sediment samples except one, collected in Boulder Creek below the upper Hillside seep at site BC028.25. The potential significance of Black Mesa Gulch as a source of copper was also suggested by the elevated levels of copper found in aquatic organisms collected in Boulder Creek downstream of Copper Creek (see ensuing section in this report).

The source of copper and sulfates in Black Mesa Gulch water was not determined by this study. Additional work by Water Resources Associates, Inc., demonstrated that water in the Gulch had two origins. One was a wash rack for Cyprus-Bagdad's ore trucks, runoff from which drained into the Gulch. This may have contributed to particulate copper loadings and the high sediment copper concentrations found near the base of the Gulch. It was also the probable source for a kerosene-like odor and an oily sheen that field workers sometimes noted. The second source for water in Black Mesa Gulch was an overtopping tank which held water pumped from Francis Creek. This water subsequently percolated through the overburden pile before surfacing in the Gulch. Weathering of sulfide minerals in the overburden is a likely source for the high sulfate levels in Black Mesa Gulch. Cyprus-Bagdad is currently taking steps to eliminate both water sources.

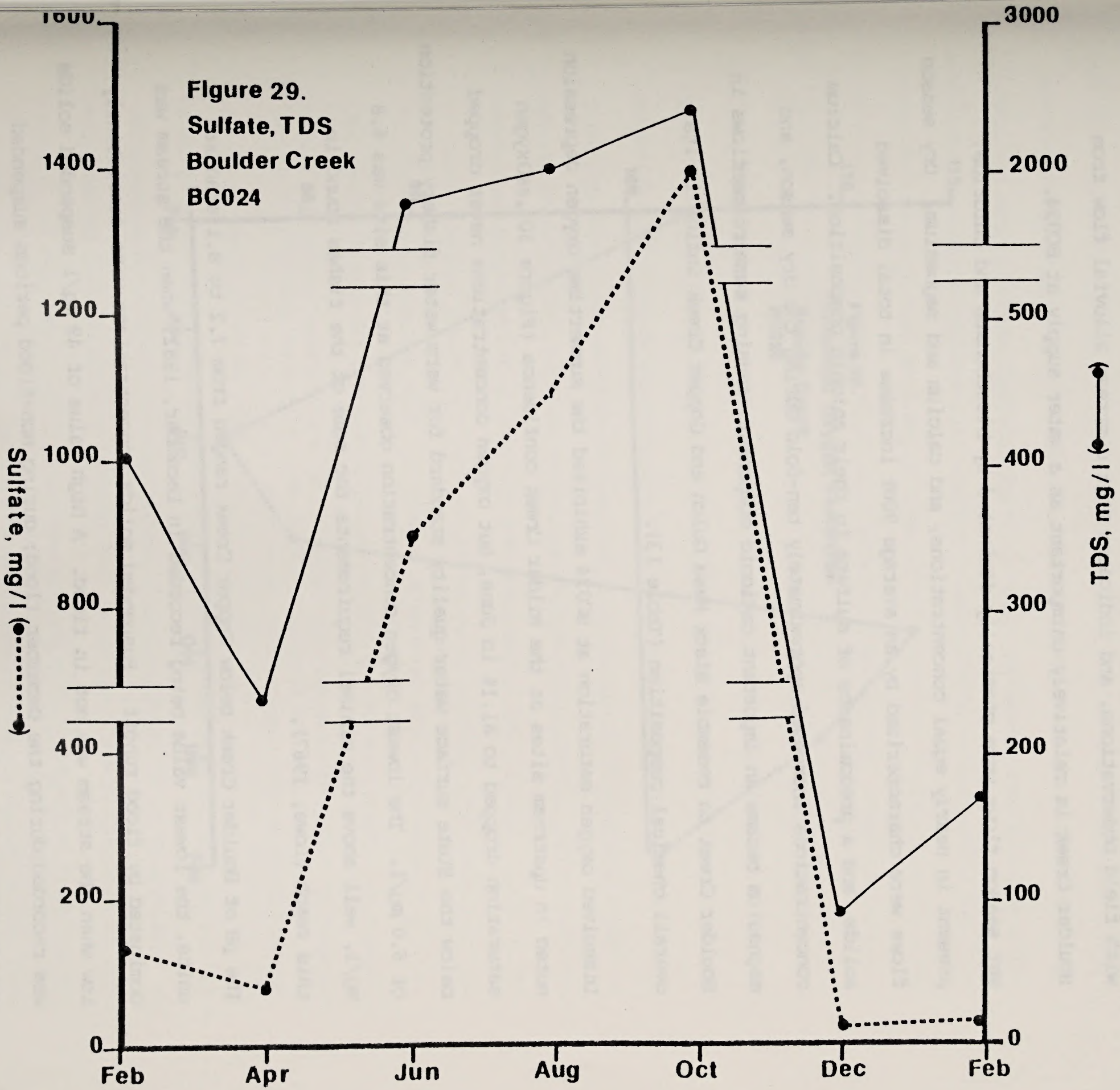
Boulder Creek below Copper Creek confluence-- Three sites were sampled in Boulder Creek below the Copper Creek confluence: Boulder Creek 100 yards below the Copper Creek confluence (site BC024); Boulder Creek below the old Cyprus-Bagdad tailings (BC023); and Boulder Creek 1/4 mile above its confluence with Burro Creek (BC021, which replaced site BC020, sampled during the Background Survey). In this stretch, Boulder Creek Canyon became wider than

at upstream sites, and the creek's bed became filled with sand and cobble alluvium, in contrast to the bedrock and boulder-lined pools that characterized upper portions of the creek. Infiltration thereby increased as presumably did insolation and resultant evaporation. Of the sites sampled in Boulder Creek below Copper Creek only one, BC024, contained permanent water.

The chemistry of Boulder Creek at BC024 clearly showed the pattern of an ephemeral stream flowing past a permanent water source. Wet season chemistry (December through April) was dominated by runoff; dry season chemistry was primarily influenced by outflow from sources in Copper Creek and Black Mesa Gulch. Transition between these two chemistries was rapid, characterized by increasing sulfate and total dissolved solids levels in summer (Figure 29; see for comparison Figure 9, page 49). A simple model was used to estimate the percentage of flow in Boulder Creek below Copper Creek that originated from sources in Copper Creek and Black Mesa Gulch (Hendrickson and Krieger, 1961; Rampe et. al., 1981). Sulfate concentrations in Boulder Creek below Copper Creek, above Copper Creek (at the Butte Creek confluence), and sources in Copper Creek and Black Mesa Gulch (taken as an average) were compared to yield an approximation of the relative importances of upstream Boulder Creek flow compared to tributary inflow at various times of the year. Error was introduced into the analysis by the use of sulfate, which is not perfectly mobile, as a tracer ion, by ignoring the role of evaporation and by not knowing the exact contributions of the three tributary sources (i.e., surface and alluvial waters in Copper Creek and water from Black Mesa Gulch). Nonetheless, the model provides information regarding the degree of dependence of Boulder Creek on these tributary sources.

Tributary sources accounted for a low of 0.2% of downstream flow during floods

Figure 29.
Sulfate, TDS
Boulder Creek
BC024



in December, 1982. During October, tributary flow accounted for 100% of surface flow in Boulder Creek below Copper Creek. The analysis agrees well with field observations, and indicates that upstream alluvial flow from Boulder Creek is relatively unimportant as a water supply at BC024.

Wet season flows were chemically dominated by bicarbonate and chloride, present in nearly equal concentrations, and calcium and magnesium. Dry season flows were characterized by an average 900% increase in total dissolved solids, and a predominance of sulfate in their anionic composition. Calcium concentrations increased approximately ten-fold during the dry season, and magnesium became an important cationic component, causing summertime flows in Boulder Creek to resemble Black Mesa Gulch and Copper Creek inflow in its overall chemical composition (Table 13).

Dissolved oxygen saturation at BC024 exhibited the summertime oxygen depression noted in upstream sites at the Wilder Creek confluence (Figure 30). Oxygen saturation dropped to 81.1% in June, but oxygen concentrations never dropped below the State surface water quality standard for warm water fishery protection of 6.0 mg/l. The lowest oxygen concentration observed at this site was 6.8 mg/l, well above the minimal requirements for some of the fishes found in this reach (Lowe, 1967).

The pH of Boulder Creek below Copper Creek ranged from 7.2 to 8.1 standard units, the lowest value being recorded in December, 1982, when the stream was dominated by flood runoff. Suspended solids concentrations were consistently low when the stream was not in flood. A high value of 49 mg/l suspended solids was recorded during the December flood; during non-flood periods suspended solids averaged 4 mg/l.

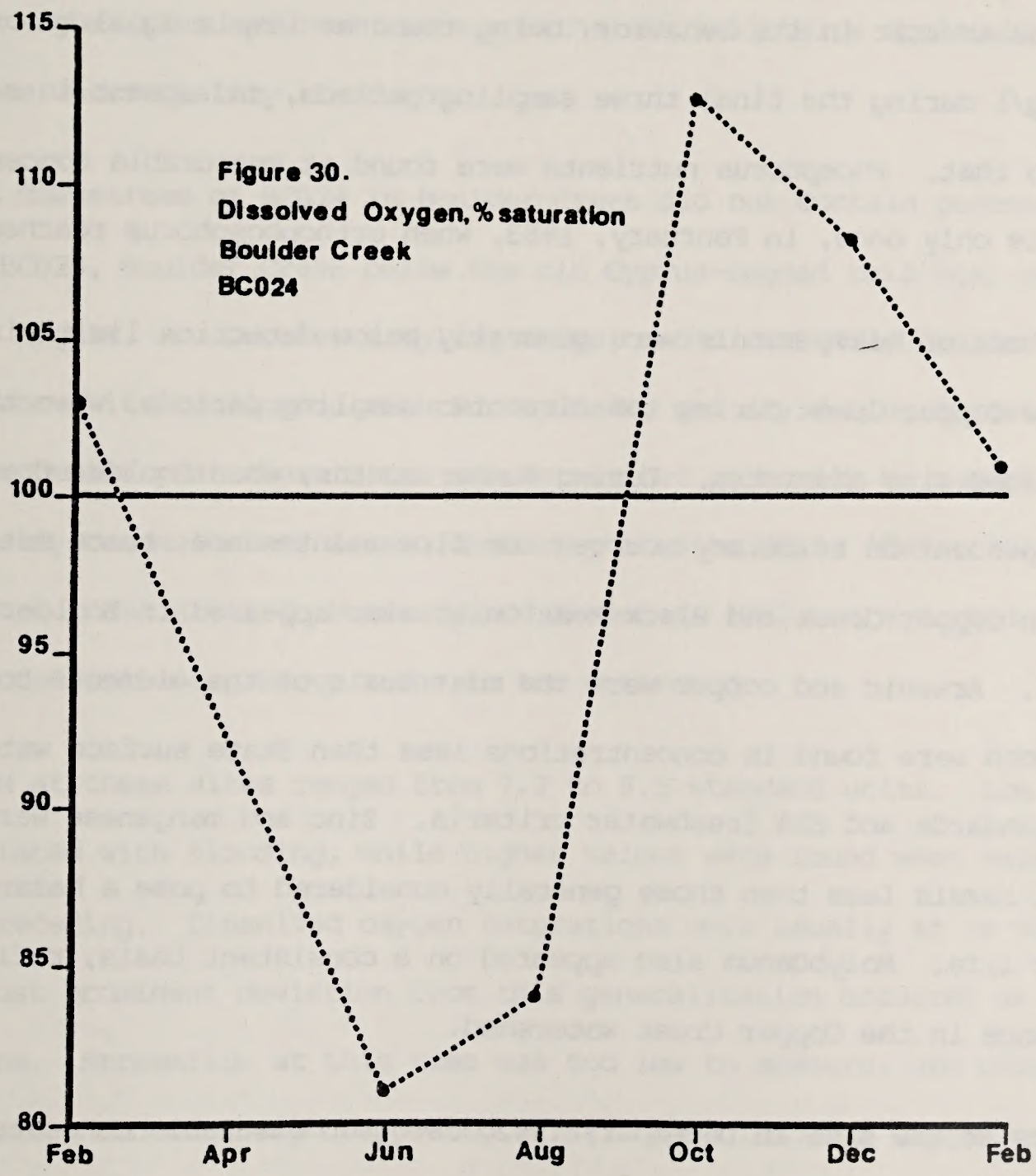


Figure 30.
Dissolved Oxygen, % saturation
Boulder Creek
BC024

Levels of nutrients in water at site BC024 were often below laboratory detection limits (Table 13), allowing little in the way of interpretation. Nitrate nitrogen was present at this site during most of the study period, in contrast to upstream sites where it was never found. This is a reflection of nitrogen input from tributary sources, particularly Black Mesa Gulch. Total Kjeldahl nitrogen was erratic in its behavior, being found at levels equal to or greater than 1.0 mg/l during the final three sampling periods, and absent in sampling previous to that. Phosphorus nutrients were found at measurable concentrations at this site only once, in February, 1983, when orthophosphorus reached 0.03 mg/l.

Concentrations of heavy metals were generally below detection limits in Boulder Creek below Copper Creek during the first two sampling periods, when throughflow dominated site chemistry. During summer months, when Boulder Creek was heavily dependent on tributary sources for flow maintenance, trace metals observed in Copper Creek and Black Mesa Gulch also appeared in Boulder Creek (Table 13). Arsenic and copper were the most toxic of the elements to appear, although both were found in concentrations less than State surface water quality standards and EPA freshwater criteria. Zinc and manganese were present at levels less than those generally considered to pose a hazard to freshwater life. Molybdenum also appeared on a consistent basis, reflecting its abundance in the Copper Creek watershed.

Floodwaters at the site in December, 1982, carried measurable concentrations of total (4.55 mg/l) and dissolved (0.16 mg/l) iron. Iron levels were also high in February, 1983, when total iron reached 0.90 mg/l and dissolved iron was measured at 0.46 mg/l. These elevated iron levels were part of a watershed wide increase in iron transport at this time, which took place in association with higher than normal turbidity levels.

Fecal coliform bacteria populations were higher in Boulder Creek below Copper Creek than at sites upstream. A population peak of 130 cfu/100 ml occurred during December flooding, and populations of 68 and 30 cfu/100 ml were found at the site during August and October, respectively. Sources for these bacteria include grazing and wildlife. Levels of bacteria at this site, while higher than upstream, were nonetheless well below applicable State surface water quality standards.

Sites downstream of BC024 in Boulder Creek did not contain permanent water. Site BC023, Boulder Creek below the old Cyprus-Bagdad tailings, was dry during June, August, and October sampling trips, and site BC021, Boulder Creek 1/4 mile above its confluence with Burro Creek, was dry during August and October. Water chemistry at these sites was determined primarily by runoff, and generally resembles wet season chemistry at site BC024 (Table 17). Samples taken at these sites in February and December, 1982, were turbid runoff waters collected following heavy rains in the watershed.

The pH at these sites ranged from 7.2 to 8.5 standard units. Low values were associated with flooding, while higher values were found when water levels were receding. Dissolved oxygen saturations were usually at or near 100%. The most prominent deviation from this generalization occurred at site BC021 in June. Streamflow at this time was too low to measure, and dissolved oxygen saturation concurrently dropped to 73.8%. The dissolved oxygen concentration at this time was 6.2 mg/l, barely above the State surface water quality standard of 6.0 mg/l.

Water at the lowermost sites in Boulder Creek was dominated chemically by the cations calcium and sodium, and contained approximately equal concentration of bicarbonate and sulfate. These two sites were higher in major ions

Table 17. Physicochemistry of lower Boulder Creek intensive survey sites. All quantities total mg/l except where noted.

Parameter	Site* BC023 (below old C-B tailings) mean	max	min	BC020, 021 (near mouth) mean	max	min
Temperature (^{o}C)	8.6	15.0	5.8	14.1	24.8	8.5
Oxygen, dissolved	11.5	12.3	10.6	9.8	11.7	6.2
TDS, residue	272	570	98	305	660	20
Total suspended solids	292	1,130	< 1	196	740	< 1
pH (standard units)	7.7	8.5	7.2	7.6	8.2	7.2
Alkalinity, $CaCO_3$	46	75	28	77	157	28
Na	12	22	3	26	67	4
Ca	21	34	12	43	94	13
Mg	6	11	2	12	34	3
K	2	3	2	4	7	3
SO_4	40	72	20	93	248	21
Cl	5	10	2	13	41	1
F	0.93	1.66	0.36	1.61	2.72	0.43
Kjeldahl-N	< 0.73	1.20	< 0.20	0.73	1.10	0.36
NO_3-N	< 0.16	0.43	0.02	< 0.14	0.49	0.02
Total PO_4-P	< 0.08	0.16	< 0.05	< 0.05	0.07	< 0.05
Cr	<0.040	0.070	<0.010	<0.028	0.060	<0.010
Cu	<0.063	0.180	<0.010	<0.054	0.140	<0.010
Fe	< 1.94	4.55	< 0.05	< 1.47	2.12	< 0.05
Mn	< 0.29	1.00	< 0.05	< 0.22	0.83	< 0.05
Mo	<0.073	0.260	<0.010	<0.021	0.047	<0.010
Zn	<0.088	0.200	<0.05	<0.072	0.160	<0.05
Fecal coliforms (cfu/100 ml)	44	44	44	43	160	< 3

* sample size for BC023 = 4; sample size for BC021 = 4; sample size for BC020 = 1.

and TDS than the uppermost site on Boulder Creek, located above Wilder Creek (Table 9, page 65). This was due in part to dissolution of bed material and concentration of solutes via evapotranspiration, processes that are particularly important in desert streams (Busch and Fisher, 1981). Mine related sources of sulfate and major cations were also responsible for these increases. TDS concentrations at BC021 reached a maximum of 660 mg/l in June, exceeding recommended drinking water limits (USPHS, 1962). Sulfate levels reached 248 mg/l at this time, exceeding a recommended limit of 90 mg/l for aquatic life (McKirdy, 1965).

Metal levels in water were generally below detection limits at these sites, particularly during non-flood periods. Total iron concentrations of up to 4.56 mg/l and total manganese concentrations of up to 1.00 mg/l were found in floodwaters, predominantly as suspended metals. Manganese was present at 0.10 mg/l at BC021 in June, due probably to concentration of solutes in the receding waters, and mobilization of manganese in the presence of low oxygen tensions. Measurable levels of total copper and zinc were inconsistently associated with floodwaters at these lowermost sites in Boulder Creek, appearing in suspended form. Chromium was found in a floodwater sample taken from the mouth of Boulder Creek in February, 1982. The metal reached a total concentration of 0.06 mg/l, consistent with the known geology of the area, which includes lenses of chromite ore (Phil Blacet, Cyprus-Bagdad, pers. comm.).

Molybdenum occurred more consistently in samples from lower Boulder Creek than any other metal. Detectable quantities of molybdenum were found in six of the nine total samples collected at sites BC020, BC021, and BC023. A maximum of 0.265 mg/l of total molybdenum was found immediately below the old Cyprus-Bagdad tailings pile in a December floodwater sample. While 94% of

this molybdenum was present as the suspended metal, this concentration was nonetheless high, comparable to molybdenum levels found in the waters of the Hillside tailings seep. The importance of this observation lies in the fact that it reveals the old Cyprus-Bagdad tailings as a source of suspended metals for downstream export during high flow regimes.

Examination of sediment data gathered from the lower Boulder Creek watershed reconfirms the old tailings' potential for metal export. All sediment samples taken immediately downstream of the tailings contained elevated copper levels. During January and February, 1983, sediment copper concentrations at this site were among the highest of any site sampled, reaching 1636 mg/kg. The temporal occurrence of sediment copper at site BC023 was the opposite of that seen for most other metals at most other sites in that concentrations were highest during the wet season and lowest at the end of the dry season. This suggests that overland runoff was the primary, if not the only means of metals export from the old tailings, which are heavily eroded and cut by gullies. Similar results were obtained by Runnells (1981), who found elevated copper concentrations in sediments below the old tailings in winter and spring, 1981. This temporal deposition pattern was in contrast to other metals sources along the creek, where metals are carried by permanent seep waters and local deposition via chemical precipitation and adsorption phenomena is most pronounced during periods when throughflow from Boulder Creek was low or lacking. Copper carried by overland runoff from the old tailings was presumably incorporated in particulate matrices, and hence not as biologically meaningful as dissolved copper emanating from other watershed sources. Sediments below the old Cyprus-Bagdad tailings were not noticeably enriched in other metals, including molybdenum.

High nutrient concentrations were observed at the lower Boulder Creek sites during flooding. Kjeldahl nitrogen concentrations reached 1.20 mg/l during December, and nitrate nitrogen reached 0.42 mg/l during February, 1982. Measurable levels of total phosphate phosphorus were recorded during February, 1982, when total PO_4-P reached 0.16 mg/l at BC023. Phosphorus was generally not detected at these sites at other times.

The highest fecal coliform bacteria count found in lower Boulder Creek was 44 cfu/100 ml, well below limits specified in State surface water quality standards. No other sample taken in the area contained fecal coliform populations in excess of 10 cfu/100 ml.

E. Biological Effects of Boulder Creek Pollutant Sources:

Sources of heavy metals such as those observed at the Hillside Mine complex can be expected to have dramatic adverse effects on local aquatic biota. Such effects were indeed observed in Boulder Creek, as many areas of the creek were devoid of plant and animal life due to dry season seepage from the Hillside complex. The ability of this study to discern the effects of pollutants on the biota of Boulder Creek was extremely limited, except in that field personnel could observe that the aquatic community was "nearly devastated", or "apparently normal." A high-resolution study of the biological effects of mine drainage on Boulder Creek (that is, a study that enumerated the intricacies of community compositions of primary producers and stream invertebrates) would be a difficult undertaking given the array of pollutants involved and the complexity of desert stream communities. The following discussion is a brief review of the effects of the pollutants found in Hillside seepage on aquatic organisms in general. Also presented are data regarding tissue levels of metals found in organisms collected from Boulder Creek.

Acidity, heavy metals, and suspended solids are the pollutants of most concern emanating from the Hillside complex. A summary of standards and criteria for these substances derived from various sources is presented in Table 1. According to these criteria, an order of the degree of aquatic toxicity of heavy metals found in Hillside seepages may be assigned as follows:

Cd>Ag>Pb>Cu>As = Se>Cr>Ni>Zn>Sb>Al>Fe = Mn.

Criteria as yet are unavailable for the following elements found in Hillside seepage: Co, Li, and Mo.

The areal extent of pollutants in Boulder Creek emanating from the Hillside mine during wet and dry seasons is shown in Tables 18 and 19, and the extent of concentrations of those contaminants which exceed one or more of the available criteria are also indicated. As expected, these tables indicate that the area available for use by aquatic organisms in Boulder Creek (as judged according to the aforementioned criteria) is larger in winter than in summer. Zinc, which with manganese was the most mobile heavy metal in the Boulder Creek system, occurred in concentrations exceeding the AFS criterion as far downstream as the Butte Creek confluence (BC027). Though generally less toxic than other heavy metals, the extent of zinc contamination in Boulder Creek makes it a pollutant of prime concern. Two highly toxic metals, arsenic and cadmium, were fairly widespread in Boulder Creek at levels considered to be biologically meaningful. Cadmium's chemical characteristics, similar in many respects to those of zinc, allow for fairly wide dispersal of this element in aquatic systems. Arsenic, though immobile in the face of ferric iron precipitation, is widely distributed geographically in Boulder Creek; it finds major sources both in the upper Hillside tailings seep and in the middle Hillside adit seep. Other toxic metals were less widely distributed. Copper, nickel, and chromium concentrations were potentially problematic only in the

Table 18. Maximum observed concentrations of heavy metals in Boulder Creek during February, April, December 1982, and February 1983 sampling All quantities total mg/l. Boxes indicate violations of USEPA and other criteria*

Site	Metal				
	As	Cd	Cu	Mn	Zn
BC029	< 0.020	< 0.005	< 0.050	< 0.050	< 0.050
BC028.5	5.500	0.008	35.000	52.000	120.000
BC028.3	0.026	< 0.005	< 0.050	0.370	0.770
BC028.1	< 0.020	< 0.005	< 0.010	< 0.050	< 0.050
BC028.2	4.640	< 0.005	< 0.010	36.900	4.500
BC028.0	< 0.020	< 0.005	< 0.010	0.060	< 0.050
BC027	< 0.020	< 0.005	< 0.050	0.190	< 0.050

*Criteria set at 200 mg/l total hardness as $CaCO_3$; Mn criterion = 1.0 mg/l (Davies and Goettl, 1977); Zn criterion = 0.10 mg/l (AFS, 1979)

Table 19. Maximum observed concentrations of heavy metals in Boulder Creek during June, August, and October sampling. All quantities total mg/l. Boxes indicate violations of USEPA and other criteria*

Site	Metal				
	As	Cd	Cu	Mn	Zn
BC029	< 0.020	0.008	0.016	0.550	< 0.050
BC028.5	34.010	0.029	430.000	90.000	500.000
BC028.3	0.910	0.037	37.200	47.900	192.500
BC028.1	0.030	0.012	0.015	24.300	10.960
BC028.2	20.600	< 0.005	0.013	45.000	9.500
BC028.0	1.200	< 0.005	0.011	30.000	4.140
BC027	0.039	< 0.005	0.017	0.340	0.210

*Criteria set at 200 mg/l total hardness as $CaCO_3$; Mn criterion = 1.0 mg/l (Davies and Goettl, 1977); Zn criterion = 0.10 mg/l (AFS, 1979)

immediate vicinity of the upper Hillside seep (BC028.5). Silver and lead, among the most toxic metals, were extremely restricted by the low solubilities of their salts, and found only in the most concentrated seepages, where the lethal effects of very high acidity and levels of other metals would likely render the effects of these two metals unimportant.

Tables 18 and 19 agree well with field observations regarding the state of the aquatic community in Boulder Creek. The most severe effects of mine drainage were noted in summer and fall, when Boulder Creek was nearly devoid of aquatic life from site BC028.5 through site BC028.0. In all cases, an apparently healthy aquatic community was noted by the time Boulder Creek reached Butte Creek, and aquatic life in Boulder Creek in the vicinity of Copper Creek was abundant. Based on available criteria, it is possible that zinc levels in Boulder Creek near Butte Creek were high enough to reduce or eliminate sensitive species, though the reported 96-hour LC_{50} for one resident species, the longfin dace (Agosia chrysogaster), was 0.79 mg/l dissolved Zn, much higher than the highest observed concentration at this site (Lewis, 1978). Inferences regarding the health of an aquatic community based on laboratory toxicity studies and water quality criteria are complicated by many factors, however. Synergistic and antagonistic effects among metals, other ions, suspended sediments and organic compounds change the toxicities of many elements, and organismal responses vary with changing acidity, temperature and chemical characteristics. Copper and zinc exhibited synergistic toxicities to Agosia in laboratory study (Lewis, 1978), and this synergy was posited as the primary factor limiting aquatic community development in French Gulch, a western Arizona stream receiving copper mine waste (Kepner, 1980). Other known metal-metal interactions as regards aquatic toxicity are summarized in Table 20. The influx of substances not generally considered toxic, such as

calcium and sulfate, may alter interspecific competitive balances and community composition; changes in algal community structure have been noted in Arizona in response to these type of changes in water chemistry (Rampe, 1979). For these reasons, suppositions as to the effects of specific mine pollutants on the biota of the Boulder Creek should be made cautiously in the absence of a detailed biological survey.

Table 20. Examples of metal-metal interactions as regards their effects on toxicity to aquatic organisms.

Metal	Effect	Reference
As	antagonizes Se toxicity;	NRC, 1977
	synergistic with Cu	"
Cd	synergistic with Cu;	ARS, 1979
	synergistic with Zn	"
Co	antagonizes Cu toxicity	Nriagu, 1979
Cu	synergistic with Zn	Lewis, 1978
$Fe^{(+3)}$	may reverse Cd toxicity	Murphy and Spiegel, 1983
Mn	antagonizes Ni toxicity	AFS, 1979
Pb	antagonizes Cu toxicity	Nriagu, 1979

Aside from toxic effects of metallic contaminants and acidity, which were only indirectly observable in this study, mine contamination had other effects that were of likely biological importance. The most noticeable of these was the formation of precipitates by oxidized metals, most notably iron and aluminum. Downstream of the upper Hillside tailings seep (BC028.5), the bottoms of pools were covered by flocculent precipitates during summer and fall. The formation of these precipitates could effectively destroy benthic plant and animal life by smothering resident organisms, and preclude recolonization by covering boulders and gravel habitats (Hynes, 1975). The presence of such a floc would probably effectively deter nest building fish such as Agosia from spawning successfully. The suspended iron precipitates formed when water from the adit seep mixed with Boulder Creek water at BC028.0 may have been directly lethal to fish and invertebrates by clogging gills with fine particulates. Certainly, the turbidity at this point was high enough to block photosynthetic activity, and light penetration was probably reduced sufficiently to impair the food gathering abilities of those organisms not actually killed by toxic metals or suspended sediments. Another result of the metals input from the adit seep was a chemical oxygen demand which, in combination with reduced photosynthesis, reduced instream oxygen concentrations by as much as 3.0 mg/l (Table 12, page 106).

The pollution emanating from the Hillside complex may have placed constraints on the ability of organisms, particularly fish, to migrate along the length of the creek in search of permanent pools during dry weather. Seasonal migration of fish species found in Boulder Creek (e.g., Gila robusta, Catostomus insignis, and Pantosteus clarki) has been documented in Aravaipa Creek in south-central Arizona; such behavior is apparently a systematic effort on the part of these organisms towards the selection of seasonally optimal habitat

(Siebert, 1980). While the exact effects of chemical barriers such as the Hillside seepage to individual desert fish species remain unknown, any such barrier to migration would likely be disadvantageous to the animals involved.

Collections of fish and frog tissue were made at three sites in Boulder Creek during October, 1982, to determine their concentrations of heavy metals and to establish the relationship, if any, between levels of heavy metals in tissues of resident organisms and heavy metal sources in the watershed (Table 21). The sampling design was somewhat compromised by a pronounced lack of cooperation on the parts of the subject organisms; still, some relationships between environmental metals sources and tissue levels of metals could be seen.

Of the five elements analyzed in tissue samples, antimony and arsenic showed no discernible patterns, either on a site by site basis or among species. Arsenic concentrations were consistently below the laboratory detection limit (5 mg/kg). Manganese, copper, and zinc showed inconsistent trends toward downstream increases in tissues of fish and frogs. Copper and manganese levels in fish (Gila robusta) were lowest near the Wilder Creek confluence and highest in the single fish caught near the Copper Creek confluence. Copper and manganese levels in this latter fish were the highest of any organism sampled in the study, pointing to the continued importance of Copper Creek and Black Mesa Gulch as sources of environmental copper, and echoing sediment sampling results for the area. The validity of these results is somewhat questionable, however, since the sample was composed of only one fish due to an equipment failure during sampling. Zinc levels in Gila robusta were lowest at the Copper Creek confluence, and highest in Boulder Creek near Butte Creek.

Table 21. Heavy metal residues in fish and frogs taken from Boulder Creek, October, 1982. All quantities mg/kg wet weight.

	Organism					
	Fish (*Gila robusta*)			Frogs (*Rana pipiens*)		
Site	Cu	Mn	Zn	Cu	Mn	Zn
BC029 (above Hillside Mine)	1.3	21.5	62.9	1.9	13.4	18.2
BC027 (Butte Creek confluence)	2.7	46.6	79.5	1.8	20.2	52.2
BC024 (below Copper Creek)	52.7	157.0	55.8	5.5	5.9	153.0

Copper in leopard frog (Rana pipens) tissue was highest below Copper Creek, although concentrations at this site were only about one-tenth those found in fish. Zinc concentrations in frog tissue increased steadily downstream reaching 153 mg/kg below Copper Creek, the highest zinc concentrations noted in aquatic organisms during the study. Manganese concentrations in frogs did not parallel those exhibited by fish; concentrations in frog tissue were lowest in organisms collected below the Copper Creek confluence. Species specific differences in metal uptake mechanisms may have been responsible for the observed differences in tissue metal levels. The uptake of zinc and other metals by organisms, and competition between metals for binding sites within organisms, takes place largely in the gut in vertebrates and is strongly influenced by gut chemistry. Interspecific differences in gut chemistry, though subtle, may ultimately be responsible for interspecific differences in tissue metal levels observed in this study.

Following the discovery that certain organic chemicals (such as organochlorine pesticides) and metals (such as mercury) could be assimilated chronically by organisms with deleterious effects, considerable study has been devoted to the uptake dynamics of other heavy metals by aquatic organisms (e.g., Murphy and Spiegel, 1982; 1983). Concern has also been voiced over the role of metals discharged by mining into Boulder Creek in causing the progressive poisoning of predators feeding on fish and frogs in the creek (Millsap, 1980). Before beginning a discussion concerning the possibility of food chain contamination by mine runoff, however, three terms should be defined (after Stokes, 1979):

Bioconcentration--the ability of an organism to concentrate a substance from the aquatic environment, including water, food, and sediment;

Bioaccumulation--the state where uptake of a substance continually exceeds excretion throughout an organism's life, resulting in continually

increasing body loads of that substance;

Biomagnification--the occurrence of a substance at progressively higher concentrations at increasing trophic levels in the food chain.

Of these three phenomena, bioconcentration has been demonstrated most widely with regard to heavy metals in aquatic systems.

Bioconcentration is a normal and often necessary process when the element concentrated is of nutritive value, as are many metals (Mertz, 1981). Table 22 gives some representative tissue levels of metals from aquatic organisms, along with their concentration factors where available (the concentration factor for any substance is its level in the organism divided by its level in the organism's environment including food, water, and other possible sources). Concentration factors are dependent upon a number of variables, including the metabolisms of individual species and environmental availability of the substance in question. The highest bioconcentration factor observed in this study was 2,550 for zinc in frogs taken in Boulder Creek below Copper Creek. Similarly high bioconcentration factors for manganese and copper were observed in fish taken from this site. These factors are only estimates which would likely be lower if the amount of ingestion of these metals from other sources (food and sediments) were known.

No data on bioaccumulation were available from this study, although this phenomenon has yet to be identified for most of the metals found in association with mine runoff of the type found in Boulder Creek. Cadmium bioaccumulation has been documented in mallards and white-tailed deer, and of the heavy metals present in mine runoff in Boulder Creek, cadmium may have the greatest propensity for food chain effects, (USEPA, 1980c; Kocan, et al., 1980). Conflicting evidence exists as to arsenic's potential for bioaccumulation in

Table 22. Metals concentrations (mg/kg wet weight) and bioconcentration factors* for fish taken from various sites in Arizona. All data from 1982 Priority Pollutant sampling (ADHS, 1982)

Fish Species	Site	Metal	Tissue Concentration	Bioconcentration Factor
Largemouth Bass, *Micropteus salmoides*	Roosevelt Lake	As	< 0.02	-
		Cd	0.22	18.3
		Cu	0.90	3.9
		Zn	19.0	513.5
Carp, *Cyprinus carpio*	Upper San Carlos Reservoir	As	0.10	6.67
		Cd	< 0.10	-
		Cu	0.40	-
		Zn	29.7	660
Largemouth Bass, *Micropteus salmoides*	Alamo Lake	As	< 0.02	-
		Cd	< 0.01	-
		Cu	0.45	-
		Zn	13.7	184
Smallmouth Buffalo, *Ictiobus bubalus*	Gila River near Arlington	As	< 0.01	-
		Cd	0.22	12.2
		Cu	1.7	70.8
		Zn	45.0	3750
Largemouth Bass, *Micropteus salmoides*	Patagonia	As	0.05	3.1
		Cd	< 0.10	-
		Cu	0.7	-
		Zn	18.1	607.7
Flathead Catfish, *Pilodictus olivario*	Yuma Canal	As	< 0.05	-
		Cd	0.30	60.0
		Cu	< 2.5	-
		Zn	65.0	-

*Bioconcentration factor = tissue concentration (mg/kg)/total water concentration (mg/l); factors unavailable when either concentration is below laboratory detection limit.

fish (AFS, 1979). Studies exist showing that zinc and chromium equilibria are established in stream invertebrates at sublethal concentrations, preventing bioaccumulation (Weiss, et al., 1980).

The very few data available concerning biomagnification of heavy metals suggest that, with the possible exceptions of cadmium and mercury, biomagnification does not exist for these elements. Limited data for various trophic levels in Boulder Creek (Kepner, 1979) suggested that tissue concentrations of copper, iron, manganese and zinc may actually decrease with increasing trophic levels. Levels of copper and manganese decreased with increasing trophic levels in areas of Pinto Creek, a stream receiving mine runoff near Globe, Arizona, while zinc levels remained fairly constant (Lewis and Burraychak, 1979). Similar results were obtained in aquatic food chain studies of copper in Ontario (Hutchinson et al., 1974) and Washington State (Funk, et al., 1975).

The data available from this and previous studies in the Boulder Creek drainage and elsewhere suggest that biomagnification of copper, zinc, manganese and arsenic is probably not significant, although resident aquatic organisms apparently concentrate copper, zinc, and manganese in response to local water and/or sediment levels of these elements.

No data exist to determine cadmium's possible role in affecting terrestrial predators via consumption of contaminated aquatic prey. Cadmium is highly toxic, fairly mobile in this system, and is known to be biomagnified, making it perhaps the most likely candidate of those metals found in the Hillside effluent for having chronic effects on terrestrial organisms.

E. Summary and Conclusions: The following conclusions may be drawn from the Intensive Survey regarding water quality in the Boulder Creek drainage:

1. The Hillside Mine complex is the most important pollution source in the Boulder Creek drainage--Mine waste enters Boulder Creek from two places at the abandoned Hillside Mine. A seep at the upstream end of the upper tailings (site BC028.5) contributes a wide array of metals, along with acid and sulfate, to Boulder Creek. A seep from a collapsed adit at the mine proper (site BC028.2) contributes high suspended solids and total metal loads. Both sources have locally devastating effects on the creek's resident biota, rendering the stream practically sterile for approximately one mile during low base flow periods. Cadmium, zinc, and manganese are the most widespread metallic contaminants emanating from the Hillside; of these, cadmium is the most toxic. Radiological contaminants were found in seeps at the Hillside at concentrations in excess of State surface water quality standards. The downstream extent of these contaminants in water and sediments during low base flow periods is unknown, and further radiological sampling of the watershed is recommended.

2. Contamination emanating from the Hillside is spatially limited and highly seasonal in its effect--While contamination from the Hillside is severe, its demonstrable effects on water quality and stream organisms are quite local. Some elevation of sulfate and metal concentrations was noted in water and sediments in Boulder Creek near Butte Creek (site BC027), a point approximately 1.5 river miles below the lowermost extent of the Hillside complex. These water quality alterations were apparently due to the influence of pollution from the Hillside, but no State surface water quality standards were

violated at this site, and the aquatic community appeared to be unaffected. Water quality near the Hillside was at its worst and the extent of poor water quality was at its greatest during late summer and early fall, when seepage from the Hillside made up a large proportion of base flow in the creek. During winter, the volume of Hillside seepage was small relative to creek flow, and the severity and areal extent of water quality problems resulting from Hillside sources were drastically reduced. Violations of State standards during these periods were confined to the sources themselves.

3. The effects of pollution entering Boulder Creek from Copper Creek have been largely abated due to hydrologic alterations of the mouth of Copper Creek, although water quality in Copper Creek is less than optimal for most uses--Aquatic communities in Boulder Creek below Copper Creek appeared to field investigators to be flourishing, having staged a recovery from their previously stressed state. Water quality in the Copper Creek drainage has improved only marginally since the late 1970's, however, and surface and alluvial waters in the drainage contained concentrations of arsenic, copper, and zinc that at times exceeded State surface water quality standards, as well as high levels of sulfate and TDS. The improvement of downstream conditions in Boulder Creek is due to reduced flow of contaminated water from Copper Creek, which has in turn been brought about by Cyprus-Bagdad's efforts to improve the recovery efficiency of their heap-leach copper operation, and by their efforts to contain runoff from seasonal precipitation. The monitor well in the mouth of Copper Creek delivers water that is unfit for human consumption and should be posted as such. The presence of ecologically significant amounts of metals in

Copper Creek mandates that surface and groundwater in the area be continually monitored.

4. The old Cyprus-Bagdad tailings contribute copper, molybdenum, and other metals to Boulder Creek but in forms that are not likely to interfere with beneficial uses--Elevated levels of total copper, molybdenum, and zinc were recorded in water samples taken below the old Cyprus-Bagdad tailings during periods of high runoff. No increases in dissolved metals were attributable to the old tailings, and no violations of State surface water quality standards were found. High copper concentrations were present in sediments collected below the old tailings in winter. Export of metals from the old tailings takes place in particulate form via erosion and overland runoff. Such metals are generally less available to aquatic organisms than those exported in dissolved form. High sediment levels of copper apparently did not inhibit community development below the old tailings; Agosia nests were observed here during the April sampling trip.

5. Aquatic organisms in Boulder Creek contained higher tissue concentrations of metals in the vicinities of known sources, but no evidence yet exists to definitely link this contamination with effects on the terrestrial food chain; other subtle biological effects remain unquantified--Tissue concentrations of copper, manganese, and zinc were generally higher in fish (Gila robusta) and frogs (Rana pipiens) collected downstream of the Hillside complex and in the vicinity of the Copper Creek confluence, as compared to organisms collected from sites without known sources for these metals. Food chain data for these metals gathered in other studies suggest that their biomagnifi-

cation potentials are limited. No data were gathered in this study to assess the food chain dynamics of cadmium, a toxic metal with bioaccumulative properties, or radionuclides in the Boulder Creek ecosystem. The potential for adverse effects of these contaminants, which find their major sources at the Hillside complex, on high trophic level aquatic and terrestrial predators cannot be dismissed. The effects of the Hillside complex as a chemical barrier to seasonal migration of native fish populations is unknown, but is likely to be detrimental to those individuals involved. Likewise, the effects of sublethal metals levels and high sulfate concentrations from sources along the creek on aquatic community composition remains unknown.

6. Large portions of Boulder Creek are either unsuited or less than optimal for the beneficial uses considered in this report -- The chemical quality of Boulder Creek deteriorated markedly in summer, due to its intermittent nature and to the presence of abandoned mining along its banks. Dissolved oxygen concentrations fell below 6 mg/l in summer at some sites, probably due to lack of flow in isolated pools. The stream contains high natural levels of fluoride, sodium, and TDS, which compromise its value as a domestic water source in summer. Areas near the abandoned Hillside mine contain concentrations of As, Cd, Cu, Mn, and Zn among other constituents, that exceed State surface water criteria for all protected uses (Table 1). Copper Creek and Black Mesa Gulch contributed sulfate levels to Boulder Creek that exceeded suggested limits for drinking water and aquatic life protection. During summer (June-October) sampling, no Boulder Creek site had chemistry that was completely acceptable in terms of meeting beneficial use criteria. During

winter, however, elevated flow caused water quality in Boulder Creek to be much better; standards and criteria violations were limited to the immediate vicinities of sources at the Hillside Mine, as well as subsurface water near the mouth of Copper Creek.

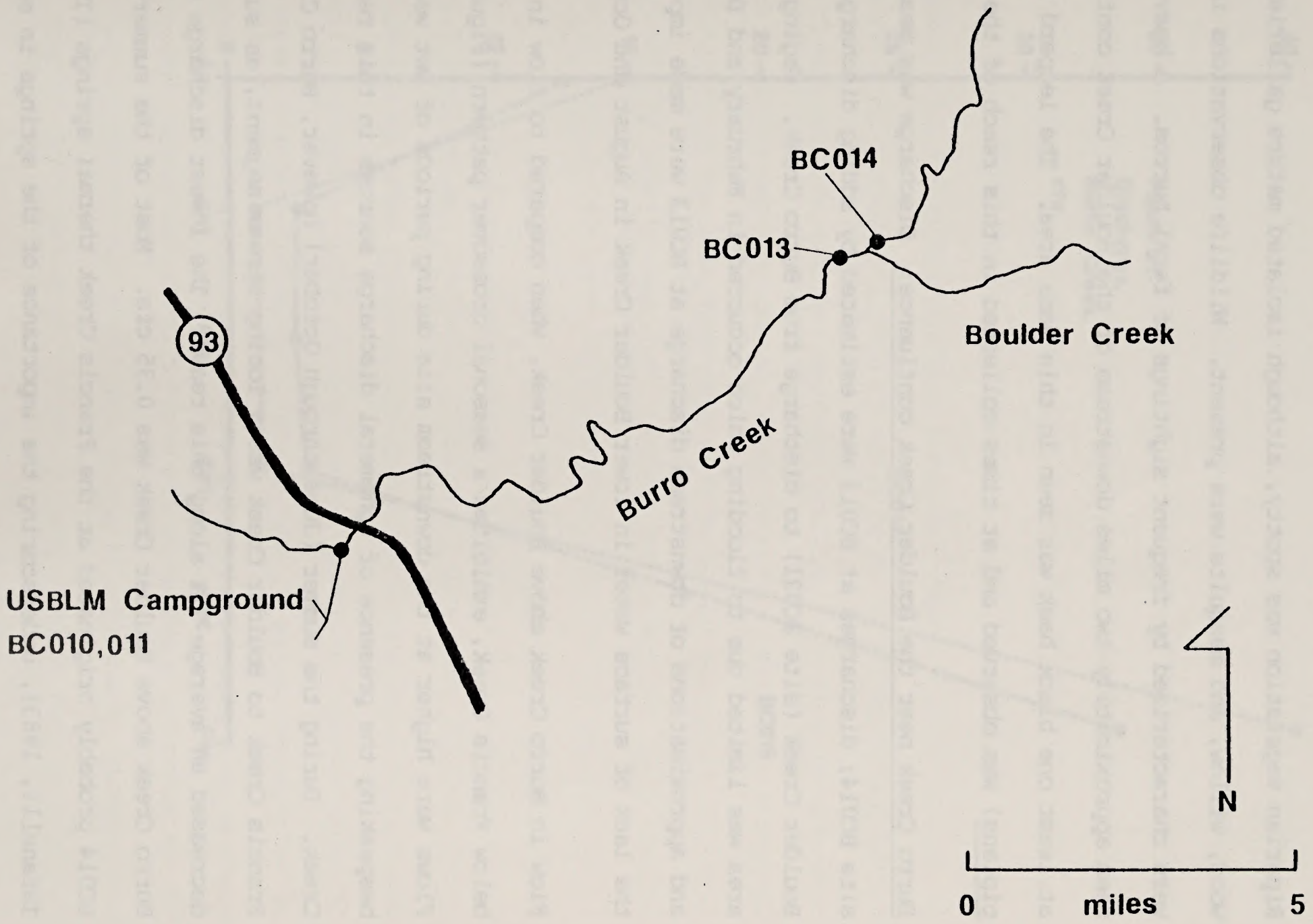
LOWER BURRO CREEK

A. Description: This portion of the study area incorporated four sampling sites, located in two rather widely separated areas (Figure 31). Sites BC013 and BC014 were located downstream and upstream, respectively, of Burro Creek's confluence with Boulder Creek, and were established to monitor the influence of Boulder Creek on Burro Creek physicochemistry. Of specific interest was the effect, if any, of sulfate and heavy metals export from mine-related sources in the Boulder Creek drainage. Site BC013 contained permanent water, occupying a sand and bedrock-lined pool in a shallow canyon, and was sampled throughout the background and intensive surveys. Site BC014 likewise contained permanent flow and was located in riffles just below a deep pool at an abandoned Cyprus-Bagdad pump station. This site was sampled at all times except February, 1982, when flooding in Boulder Creek prohibited access.

Sites BC010 and BC011 were located in the vicinity of the USBLM campground downstream of the U.S. Highway 93 bridge. They were established to monitor the effect of recreational use of the campground on instream water quality. Both contained permanent flow. BC011 was located approximately 200 yards upstream of the campground toilet facilities; samples were taken in a sandy, braided channel choked with seepwillow. Site BC010 was located just downstream of the old Highway 93 bridge, near USGS gage number 09424447. The creek at this point was a sand-bottomed run. BC010 was sampled throughout the background and intensive surveys, and site BC011 was sampled throughout the intensive survey, beginning in April.

Burro Creek's aspect in this portion of the study area was similar to that of the upper reaches of the creek discussed previously in this report. The stream occupied canyons as well as open valleys, flowing through sandy runs,

Figure 31.
Lower Burro Creek



cobbled riffles, and occasional deep pools. Pools, such as the one at BC014, provided habitat that was apparently excellent for suckers and Gila chubs. Riparian vegetation was spotty, although isolated mature galleries of cottonwood, willow, and mesquite were present. Wildlife observations in the area were characterized by frequent sightings of feral burros. A beaver dam was seen approximately two miles downstream of the Boulder Creek confluence, and at least one black hawk was seen in this same area. The leopard frog (Rana pipiens) was observed and at times collected in this reach of the creek.

B. Burro Creek near the Boulder Creek confluence: Discharge was measured at site BC014; discharges at BC013 were estimated by adding discharge from Boulder Creek (site BC021) to discharge from Burro Creek. Gaging in this area was limited due to flooding which occurred in February and December, 1982, and approximations of downstream discharge at BC013 were made impossible by the lack of surface water in lower Boulder Creek in August and October.

Flow in Burro Creek above Boulder Creek, when compared to flow in Burro Creek below Francis Creek, exhibited a seasonal crossover pattern (Figure 32). Flows were higher at the downstream site during periods of wet weather, bespeaking the presence of ephemeral discharge sources in this reach of Burro Creek. During the summer (June through October) however, Burro Creek from Francis Creek to Boulder Creek was a losing stream segment, as surface discharge decreased an average 72% along this reach. The lowest discharge observed in Burro Creek above Boulder Creek was 0.35 cfs. Most of the summertime flow at BC014 probably originated at the Francis Creek thermal springs (Turner and Tafanelli, 1983), underscoring the importance of the springs in maintaining discharge along this reach of Burro Creek.

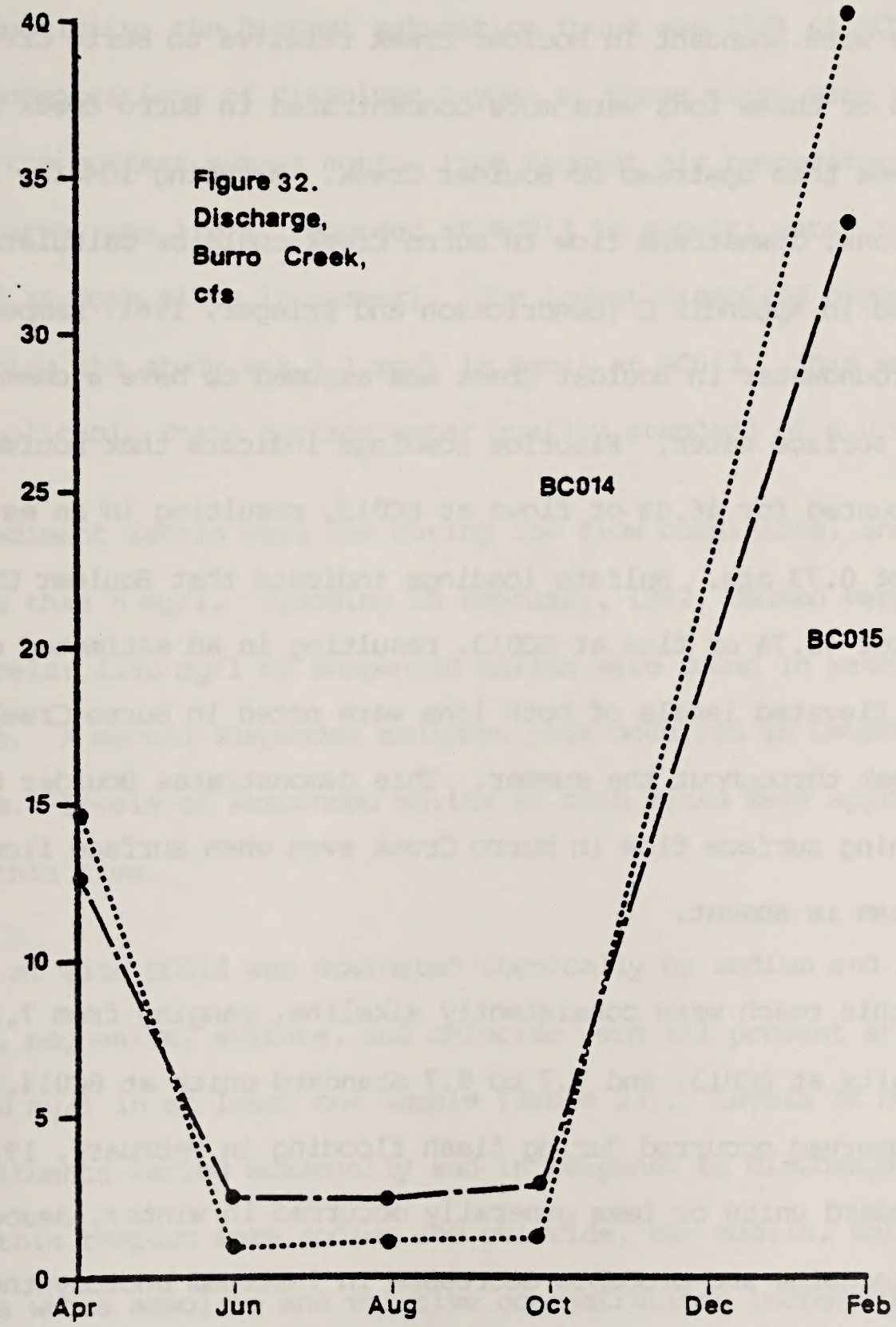


Figure 32.
Discharge,
Burro Creek,
cfs

Estimates of discharge were made for site BC013 in June, when water quality data were available for the station near the mouth of Boulder Creek. Fluorides and sulfate were abundant in Boulder Creek relative to Burro Creek at site BC014; both of these ions were more concentrated in Burro Creek downstream of Boulder Creek than upstream of Boulder Creek. By using loading rates for these two ions, downstream flow in Burro Creek could be calculated as demonstrated in Appendix C (Hendrickson and Krieger, 1961; Rampe, 1981). Alluvial groundwater in Boulder Creek was assumed to have a chemistry similar to that of surface water. Fluoride loadings indicate that Boulder Creek inflow accounted for 46.4% of flows at BC013, resulting in an estimated discharge of 0.73 cfs. Sulfate loadings indicate that Boulder Creek inflow accounted for 48.7% of flow at BC013, resulting in an estimated discharge of 0.76 cfs. Elevated levels of both ions were noted in Burro Creek below Boulder Creek throughout the summer. This demonstrates Boulder Creek's role in maintaining surface flow in Burro Creek even when surface flow in the former stream is absent.

Waters in this reach were consistently alkaline, ranging from 7.2 to 8.6 standard units at BC013, and 7.7 to 8.7 standard units at BC014. The lowest pH value observed occurred during flash flooding in February, 1982. Values of 8.0 standard units or less generally occurred in winter, associated with elevated discharge and probable decreases in instream photosynthentic rates. The pH at BC014, upstream of the Boulder Creek confluence, was slightly but consistently higher than at BC013, the downstream pH decline perhaps resulting from mixing with Boulder Creek's waters, which had lower ambient pH levels than Burro Creek (see Table 17, page 132).

Dissolved oxygen saturations in this reach of Burro Creek manifested summertime

maxima typical of Burro Creek (Figure 33), indicating that throughflow at these sites, however minimal at times, was adequate to maintain high instream primary productivity; the highest saturation found was 152% at BC013 in October. Concentrations of dissolved oxygen at these sites were always high, even during the hottest summer months (the highest air temperature observed during the survey was 113°F, recorded at BC013 in August; water temperatures reached 30°C at both sites in summer). The lowest dissolved oxygen level observed during the study was 9.1 mg/l in April at BC013. This was well above the applicable State surface water quality standard of 6.0 mg/l.

Suspended sediment levels were low during low flow conditions, and were usually less than 5 mg/l. Flooding in February, 1982, caused very high sediment levels; 1250 mg/l of suspended solids were found in water at BC013 at this time. A second suspended sediment peak occurred in December following winter rains. Levels of suspended solids at both sites were approximately 60 mg/l at this time.

Burro Creek at site BC014 was dominated chemically by sodium and bicarbonate, but calcium, magnesium, sulfate, and chloride were all present at concentrations exceeding 20 mg/l in at least one sample (Table 23). Levels of most major ionic constituents varied seasonally and in response to discharge. Particularly notable in this respect were sodium and chloride, two mobile, soluble constituents whose absolute and relative concentrations increased greatly during summer. Sodium reached a maximum concentration of 109 mg/l in August, exceeding recommended drinking water limits (NRC, 1977). Total dissolved solids levels at BC014 averaged 333 mg/l during summer (June through October), as compared to 258 mg/l at BC015, located just downstream of Francis Creek. This downstream increase was probably due to concentration of solutes via

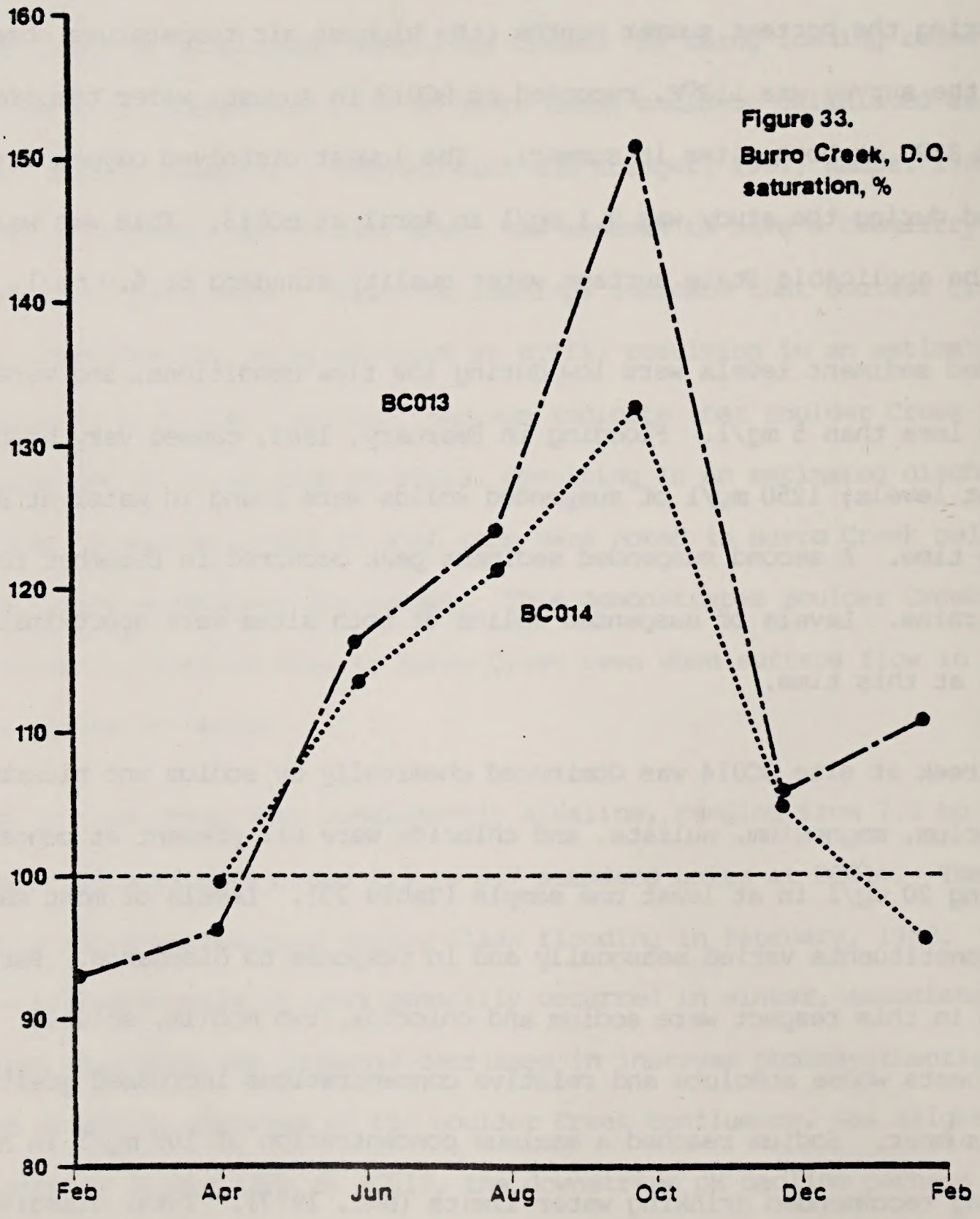


Figure 33.
Burro Creek, D.O. saturation, %

Table 23. Physicochemistry of Burro Creek intensive survey sites near the Boulder Creek confluence. All quantities total mg/l except where noted.

Parameter	Site BC014 (above Boulder Cr.) mean	max	min	BC013 (below Boulder Cr.) mean	max	min
Temperature (°C)	17.7	30.0	7.0	17.9	30.0	7.5
Oxygen, dissolved	10.8	12.8	9.2	10.9	13.7	9.1
pH, standard units	8.2	8.7	7.7	8.0	8.6	7.2
TDS, residue	259	456	426	344	538	126
Total suspended solids	12	62	< 1	188	1,250	< 1
Alkalinity, $CaCO_3$	141	252	52	118	218	44
Na	42	109	< 10	37	89	5
Ca	30	42	16	36	61	17
Mg	10	22	4	13	26	2
K	6	13	1	6	10	3
SO_4	16	32	11	52	127	18
Cl	20	56	2	19	51	2
F	0.41	0.74	0.20	0.87	1.51	0.24
Kjeldahl-N	< 0.81	1.60	< 0.20	< 0.82	2.00	< 0.20
NO_3-N	< 0.07	0.15	0.04	< 0.12	0.47	0.02
Total PO_4-P	< 0.05	0.08	< 0.05	< 0.07	0.15	< 0.05
As	ND	ND	ND	< 0.21	0.30	< 0.02
Cu	<0.037	0.087	<0.010	<0.032	0.070	<0.010
Fe	< 0.95	4.65	< 0.05	< 1.28	4.65	< 0.05
Mn	<0.051	0.06	< 0.05	< 0.19	1.02	< 0.05
Mo	<0.010	0.012	<0.010	<0.011	0.019	<0.010
Zn	ND	ND	ND	<0.06	0.11	< 0.05
Fecal coliforms (cfu/100 ml)	39	210	< 2	32	100	< 2

ND - not detected
* sample size for BC014 = 6; sample size for BC013 = 7.

evapotranspiration and dissolution of bed material. Sodium and chloride increases may have been the result of as yet undocumented spring inputs along this reach. The recommended drinking water limit for TDS (500 mg/l; USPHS, 1962) was not exceeded at site BC014 during the intensive survey.

Silica concentrations were low at site BC014 compared to water sampled upstream in the drainage, which had high silica concentrations derived from the Francis Creek thermal springs (see Table 5, page 27). The drop in concentration noted for silica was the opposite of the pattern observed for most ions, whose concentrations tended to increase in a downstream direction in Burro Creek. The silica decrease may be the result of precipitation of silica as equilibrium is achieved between bed materials and waterborne silica (Edwards and Liss, 1973). Fluoride levels at BC014 were generally low, and did not approach recommended drinking water limits (approximately 1.0 mg/l; USPHS, 1962).

As mentioned previously, inflow from Boulder Creek had an effect on Burro Creek chemistry even at times when no Boulder Creek surface flow was evident. The effects were characterized by increases in calcium, sulfate, and fluoride concentrations, and decreases in concentrations of sodium and potassium (Table 23, Figures 34, 35). Fluoride increases were most significant from a management standpoint, since levels of this ion exceeded recommended drinking water limits in Burro Creek below Boulder Creek during summer. The influence of Boulder Creek on Burro Creek chemistry appeared to be greatest in June, waning through the remainder of the summer, indicating a decrease in Boulder Creek's contribution to Burro Creek discharge as the dry season progressed.

Boulder Creek did not measurably increase heavy metal concentrations in Burro Creek during the intensive survey. Chromium, copper, iron, manganese, and zinc were present in sediment-laden floodwaters taken from BC013 in

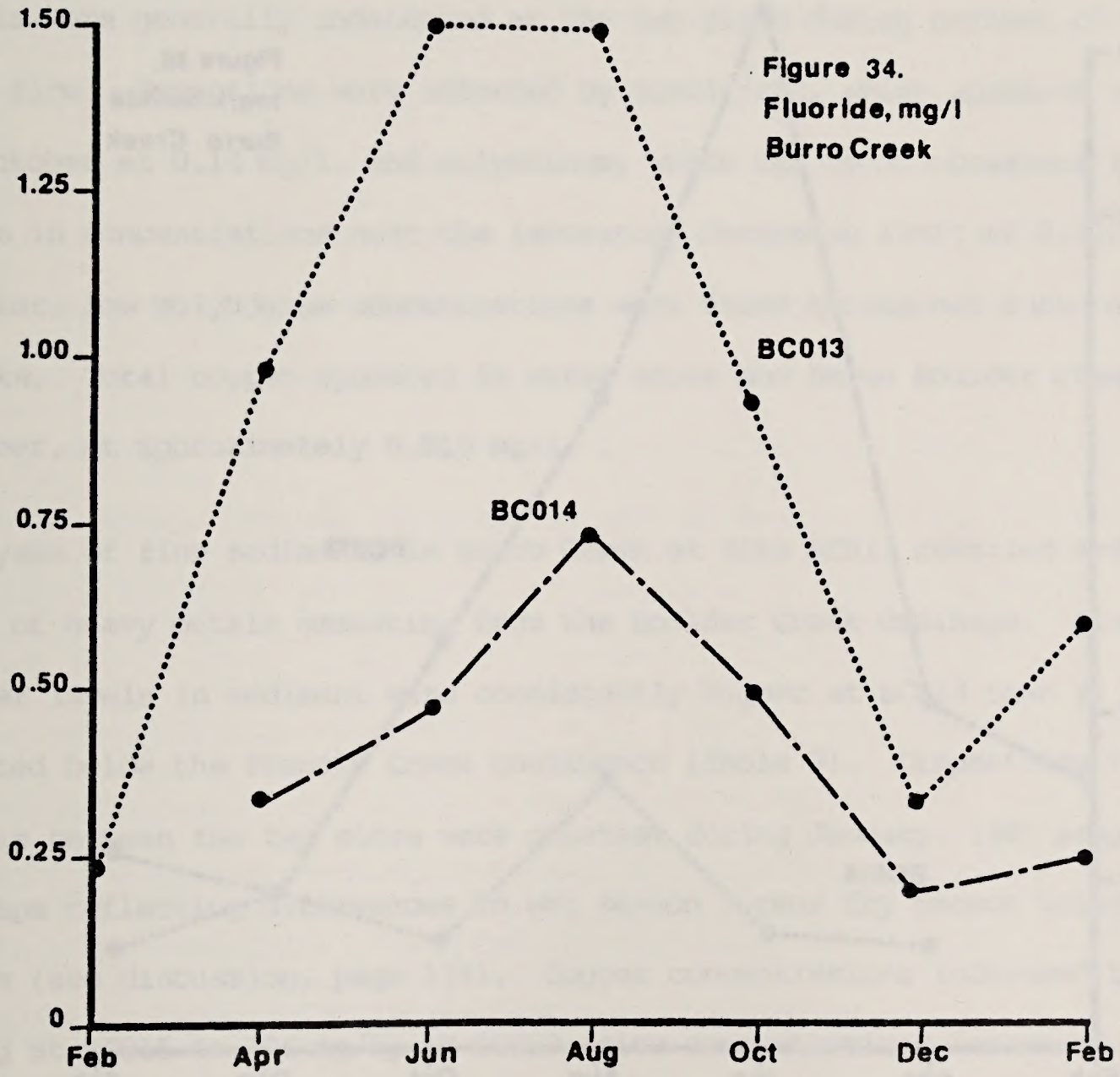


Figure 34.
Fluoride, mg/l
Burro Creek

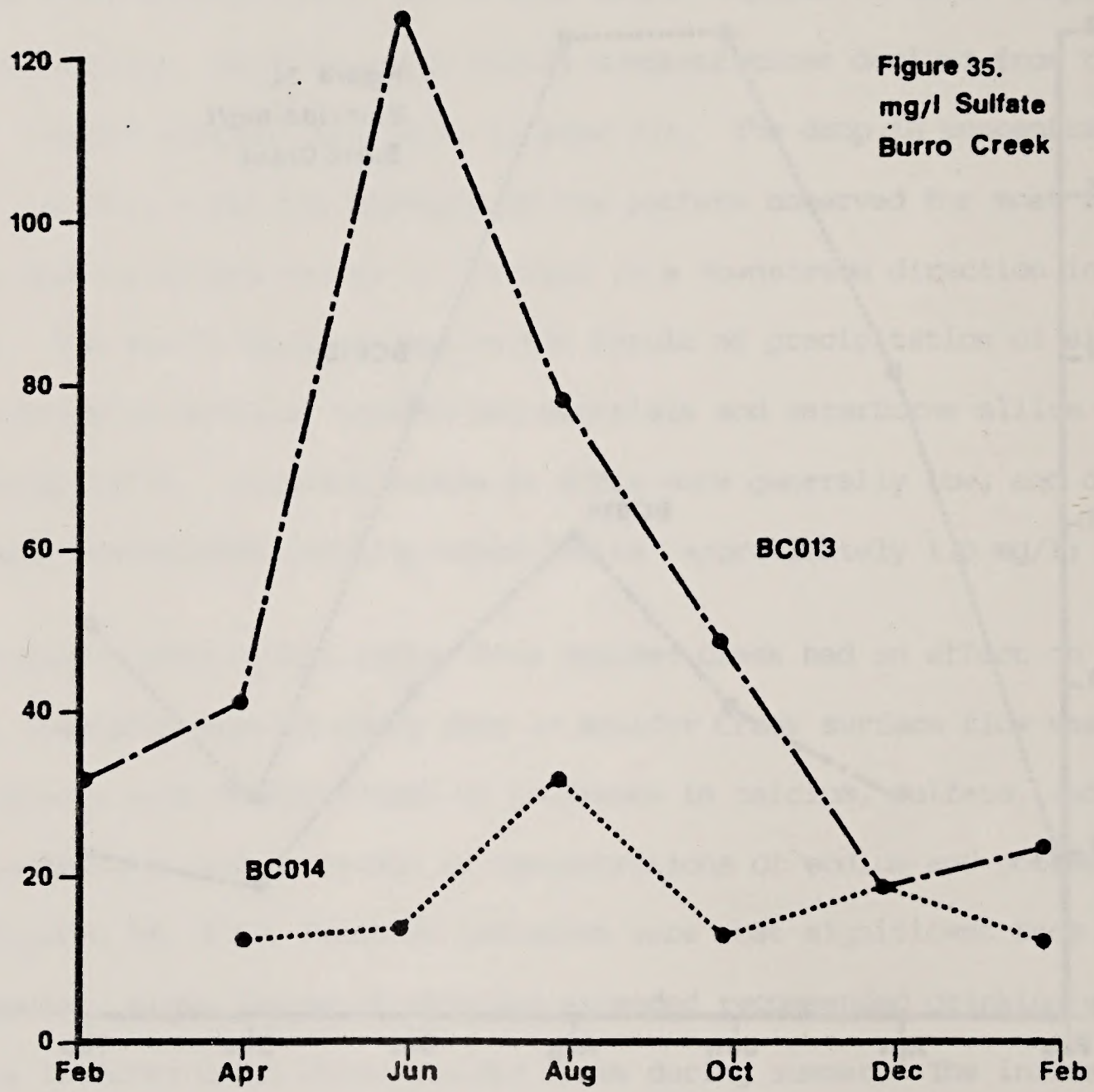


Figure 35.
mg/l Sulfate
Burro Creek

February, 1982. Most of these metals were present in association with suspended solids, and at concentrations well below applicable State standards. No data are available from BC014 at this time. During periods of increased discharge in December and February, 1982-83, iron and manganese were found at both sites at comparable concentrations, largely in suspended form (Table 23). Metals were generally undetected at the two sites during periods of stable base flow. Exceptions were afforded by total iron, which appeared at BC013 in October at 0.14 mg/l, and molybdenum, which was found occasionally at both sites in concentrations near the laboratory detection limit of 0.010 mg/l. Similar, low molybdenum concentrations were found throughout Burro and Francis Creeks. Total copper appeared in water above and below Boulder Creek in October, at approximately 0.015 mg/l.

Analyses of fine sediments in Burro Creek at site BC013 revealed slight enrichment of heavy metals emanating from the Boulder Creek drainage. Zinc and copper levels in sediment were consistently higher at BC013 than at BC015, located below the Francis Creek confluence (Table 7). Disparities in metals levels between the two sites were greatest during January, 1983 sampling, perhaps reflecting differences in wet season versus dry season transport modes (see discussion, page 134). Copper concentrations increased from 30.9 mg/kg at BC015 to 305 mg/kg at BC013; zinc concentrations increased from 23.3 mg/kg to 73.6 mg/kg over the same stretch. In addition to copper and zinc, other metals including chromium, lead, iron, and manganese showed signs of downstream sediment enrichment. With the exception of the aforementioned high copper value, most heavy metal levels encountered in sediments at BC013 were lower than those found in association with known metal sources in the Boulder Creek drainage.

Leopard frog (Rana pipiens) tissue samples were taken from BC013 in October and analyzed for antimony, arsenic, copper, manganese, and zinc (Table 24). As with samples taken in other portions of the watershed, antimony levels did not show a discernible pattern, and concentrations of arsenic in tissue were below laboratory detection limits (5 mg/kg). Concentrations of copper and zinc in frogs taken from Burro Creek below Boulder Creek were higher than in frogs taken near the confluence of Boulder and Wilder Creeks, above known sources of metal contamination. It is likely that these tissue results were due to metal influxes from sources along Boulder Creek, namely, the Hillside complex, Black Mesa Gulch, Copper Creek, and the old Cyprus-Bagdad tailings. It seems reasonable that the primary method of entry of metals into the Burro Creek food chain, if not the frogs themselves, is via ingestion of sediments, since amounts of metals in the water column were usually very low at site BC013.

Table 24. Levels of heavy metals in frogs (Rana pipiens) collected in Boulder Creek near Wilder Creek (BC029) and Burro Creek below Boulder Creek (BC013). Values are mg/kg wet weight.

	Metals		
Site	Cu	Mn	Zn
BC029	1.9	13.4	18.2
BC013	4.2	4.0	34.6

Levels of metals found in frogs at BC013 were, however, lower than those from frogs living in close proximity to the Hillside Mine (site BC027) and Black Mesa Gulch and Copper Creek (site BC024), indicating a progressive decline in tissue concentrations of heavy metals as the distance from Boulder Creek contaminant sources increased. The recognizable increase in levels of copper and zinc in tissue and sediments at BC013, compared to uncontaminated portions of the drainage, did not appear to have an adverse effect on the resident biota. Organisms in the Burro Creek riparian community downstream of Boulder Creek were numerous and diverse; primary productivity at BC013, as measured by dissolved oxygen saturations, was unabated by Boulder Creek inflow. The metals found in Burro Creek frogs (copper, manganese, and zinc) have low biomagnification and bioaccumulation potentials (see discussion, page 144). Cadmium, perhaps the most dangerous pollutant in the drainage in terms of potential food-chain effects, was not monitored in frog tissue but appeared only at low levels ($\leq$ 1 mg/kg) in sediments at BC013. It appeared from intensive survey observations that, while metals exports from Boulder Creek increased concentrations of heavy metals in the sediment and biotic compartments of the downstream Burro Creek ecosystem, these phenomena did not adversely affect the integrity of the biotic community therein, at least on the rather rough scale of resolution allowed by the study design.

Radiochemical parameters (total gross alpha and total gross beta activities and total uranium) were analyzed in water collected at BC013 in February, 1983. None of these parameters was present at levels that reached laboratory detection limits, which were 3 picoCuries/liter for alpha and beta activity and 0.001 mg/l for total U.

Nitrate nitrogen was usually present at these two Burro Creek sites in concentrations near or below laboratory detection limits. During periods of high runoff, nitrate was flushed into the creek from the surrounding watershed, resulting in a maximum nitrate nitrogen value of 0.46 mg/l, recorded at BC013 during the February, 1982 flood. Higher than normal nitrate nitrogen concentrations were observed at both sites sampled during high water in December, when concentrations at both sites were approximately 0.15 mg/l as N. High nutrient fluxes are commonly associated with flooding in desert watersheds, and may form a large portion of the annual nutrient budget of many desert waters (Fisher and Minckley, 1976; Minckley and Sommerfeld, 1979).

Kjeldahl nitrogen levels at both sites peaked in December, again in probable response to high water levels. High levels of Kjeldahl nitrogen were not found at BC013 during the February, 1982 flood, however. Concentrations of Kjeldahl nitrogen increased from April through August at both sites, paralleling the pattern observed for upstream sites on Burro and Francis Creeks.

Phosphorus data gathered for the two sites were somewhat erratic. In addition to questionable data gathered in August, December ortho (dissolved) phosphate phosphorus values were considerably higher than total phosphate phosphorus values. Data obtained for other sampling periods conform to the pattern observed for other portions of the watershed in that measurable phosphorus values tended to occur during periods of high discharge. As with other portions of the watershed, phosphorus was the nutrient most likely to become limiting to plant growth in this portion of Burro Creek.

Fecal coliform bacteria populations were low during stable flow periods and generally did not exceed 20 cfu/100 ml at those times (April through October).

Low fecal coliform populations occurred in spite of obvious use of the area for grazing. Bacterial levels peaked during December, as high water washed in organisms from the surrounding watershed and suspended those present in stream sediments.

C. Burro Creek at USBLM Campground: Discharge for this reach of Burro Creek was recorded in two ways. Field personnel measured discharge at site BC010 during June, August, October, and December. Flow measured in this way varied from 0.52 cfs in October to 131.9 cfs in December. USGS records from the gage at the old Highway 93 bridge (gage number 09424447) were also utilized and showed that discharge during the study ranged from a minimum of 0.5 cfs to a maximum of 31,000 cfs, the latter value occurring March 3, 1983. Some disparities exist between ADHS and USGS data during low flow periods; ADHS field methodology probably produced more accurate results at these times. Both sites in this area contained permanent flow throughout the background and intensive survey period, though very low discharges were encountered in late summer and early fall. In spite of chemically recognizable flow augmentation from Boulder Creek and springs in the vicinity of the U.S. Highway 93 bridge, flow declined during dry periods from site BC014 (Burro Creek above Boulder Creek) to site BC010.

Both sites near the campground were consistently well-oxygenated and had high pH values, indicating the productive nature of the stream in this area. Dissolved oxygen saturations varied seasonally, exhibiting the late summer maxima observed at other sites along Burro and Francis Creeks. Dissolved oxygen saturation reached 170% at BC010 in October, the highest supersaturation level recorded during the survey. Simultaneously, pH reached 9.0 standard units, again the highest recorded value in the survey. Saturation at BC011 reached 150% at that time, with a concurrent pH value of 8.9 standard units,

indicating that productivity was high throughout this reach of Burro Creek. Productivity was maintained in part by high nitrate nitrogen levels in this stretch of the Creek (see ensuing discussion). During summer and early fall, volumes of water at both sites were low, and the stream supported lush growths of periphytic algae and submersed macrophytes, including Myriophyllum, Potamogeton, and Marsilea, an aquatic fern. As a result, the physicochemistry of Burro Creek in this area was largely determined by photosynthetic processes.

Burro Creek waters in the vicinity of the USBLM campground were dominated chemically by the cations sodium and calcium, and the anions bicarbonate and sulfate (Table 25). Waters at the two sites were similar to one another in their ionic makeup, and generally similar to those collected at Burro Creek immediately below its confluence with Boulder Creek (site BC013). Sulfate's relative importance at these lowermost Burro Creek sites is traceable to mine-related sources in the Boulder Creek watershed, although sulfate concentrations in water near the campground never exceeded limits recommended for fish and aquatic life protection (McKirdy, 1968) or drinking water supplies (USPHS, 1962). Fluoride levels reached or exceeded recommended drinking water limits at both sites during summer (USPHS, 1962); these levels were comparable to those observed at site BC013 and probably originate from Boulder Creek.

Heavy metals were generally not detected in waters near the campground during periods of low flow. Total copper was found at both sites in October, however, reaching 0.015 mg/l at BC010 and 0.013 mg/l at BC011. Copper appeared in Burro Creek immediately below Boulder Creek (site BC013) at this time at similar concentrations, but did not appear at upstream sites in the Burro and Francis Creek watersheds. Copper also appeared at BC011 in August at 0.015 mg/l. No measurable dissolved copper was found in this reach of Burro Creek;

Table 25. Physicochemistry of Burro Creek near the USBLM campground. All quantities mg/l except where noted.

Parameter	BC011 (above campground)			BC010 (below campground)		
	mean	max	min	mean	max	min
Temperature (^{o}C)	8.0	30.0	7.0	17.6	30.0	7.3
Oxygen, dissolved	10.8	13.2	7.4	11.0	14.8	7.1
pH (standard units)	8.3	8.6	8.1	8.3	9.0	7.3
TDS, residue	323	520	187	300	397	204
Total suspended solids	3	10	< 1	3	11	< 1
Alkalinity, $CaCO_3$	111	132	78	101	127	58
Na	41	57	21	36	58	7
Ca	35	42	26	33	42	24
Mg	14	22	7	12	20	5
K	7	10	4	7	10	4
Cl	32	54	9	28	54	4
SO_4	51	67	26	50	74	27
F	0.99	1.18	0.66	0.86	1.16	0.28
Kjeldahl-N	< 0.47	0.80	< 0.10	< 0.43	0.80	< 0.20
Nitrate-N	< 0.46	1.22	< 0.09	0.23	0.50	0.03
Total PO_4-P	< 0.05	0.06	< 0.05	< 0.09	0.28	< 0.05
As	ND	ND	ND	< 0.20	0.22	< 0.20
Cu	<0.027	0.025	<0.010	<0.045	0.150	<0.010
Fe	< 0.34	1.34	< 0.05	< 0.53	1.73	< 0.05
Mn	ND	ND	ND	< 0.22	1.21	< 0.05
Mo	<0.013	0.018	<0.010	<0.013	0.024	<0.010
Zn	ND	ND	ND	<0.063	0.140	<0.050
Fecal coliforms (cfu/100 ml)	12	40	< 2	5	12	< 2

ND - not detected
* sample size for BC011 = 6; sample size for BC010 = 7.

total copper concentrations were much lower than the applicable State surface water quality standard (0.50 mg/l) and EPA's criterion for the protection of aquatic life and wildlife (approximately 0.040 mg/l; USEPA, 1980). Molybdenum was present on a fairly consistent basis at both sites, at levels near the laboratory detection limit of 0.010 mg/l. Antimony was found at both BC010 and BC011 in August, reaching a maximum concentration of 0.015 mg/l, well below levels that would jeopardize instream protected uses (USEPA, 1980a). Some difficulty was encountered in verifying low antimony levels in these and other samples.

Heavy metal transport did occur in association with flood flows, mostly as suspended metals. Copper, iron, manganese, and zinc were recorded in flood waters at BC010 in February, 1982, and copper, iron, and molybdenum were found at both sites in the high, turbid waters sampled in December. While some of this metallic load may have originated at contaminant sources in the Boulder Creek watershed, metals appearing in the lower reaches of Burro Creek were for the most part in forms that did not pose a hazard to aquatic communities.

Nitrate nitrogen concentrations were high during low flow periods at BC011, reaching 1.2 mg/l in October. Concentrations decreased at BC010; nitrate nitrogen at that site was 0.5 mg/l. The presence of high nitrate levels during periods of low discharge indicates a point source in the area. A possible source for nitrates is present in the form of flush toilet facilities at the campground. The leach line disposal system from these facilities extends downstream and is away from the main channel, however, and would be more likely to influence water quality at site BC010 than at site BC011. Also, other indicators of septic pollution, such as bacteria, organic nitrogen,

and chloride were not present in Burro Creek in amounts consistent with this explanation for the elevated nitrate levels. Previous USBLM investigations have shown the presence of springs near the U.S. Highway 93 bridge, located approximately 1/2 mile upstream of site BC011. Though not sampled during the background or intensive surveys, these springs are a probable source of nitrates, since other springs in the drainage such as those in Francis Creek and Black Mesa Gulch have comparably high nitrate levels. The highest nitrate nitrogen concentration observed in Burro Creek near the campground was approximately an order of magnitude lower than the recommended drinking water limit of 10 mg/l as N (USPHS, 1962). Levels were high enough to support a lush instream plant community, however, which in turn resulted in the high pH and dissolved oxygen levels observed at these sites. As with other nitrate-rich waters in the drainage, nitrate in Burro Creek near the campground was probably natural in origin, since manufacturing, disposal, and agricultural sources for the ion were lacking in the watershed (Brown and Caldwell, 1979; NAS, 1972).

Kjeldahl nitrogen at these two sites generally increased in late summer and was present in the samples taken during high flows in winter. This pattern of Kjeldahl nitrogen variation was similar to that observed at other Burro Creek sites, and was probably linked to nitrogen transformations by resident biota during the growing season, and transport during high flows. The highest observed Kjeldahl nitrogen concentration at these two sites was 0.80 mg/l, recorded at both sites during February, 1983.

Total and dissolved phosphate phosphorus concentrations were generally at or below laboratory detection limits during low water periods. Detection limits were 0.050 mg/l for total phosphate phosphorus, and 0.010 mg/l for dissolved

phosphate phosphorus. Flood flows contributed relatively nigh phosphorus concentrations to the stream; 0.280 mg/l total phosphate phosphorus was present at BC010 during the flash flooding in February, 1982.

Fecal coliform bacteria populations were generally low at both sites during the intensive survey, and did not reveal any impacts of campground facilities, instream recreation, or grazing on water quality in Burro Creek. The highest fecal coliform population observed at either site was 40 cfu/100 ml at BC011 in August; no increase in fecal coliform levels was noted downstream of the campground toilet facilities. Intensive instream recreation has been linked to high fecal coliform levels in some Arizona streams (NACOG, 1978), although other reports suggest that streamside campgrounds with modern facilities may be compatible with maintenance of good stream water quality (Gary, 1982). While the campground currently does not pose a threat to Burro Creek water quality, future monitoring seems justified to insure continuing water quality protection.

D. Summary and Conclusions: The following conclusions may be drawn from the intensive survey regarding water resources in this reach of Burro Creek:

1. During dry periods, discharge decreased in Burro Creek along the segment extending from site BC014 above Boulder Creek to site BC010 below the USBLM campground: This portion of Burro Creek is a losing segment in summer in spite of chemically recognizable inputs of water from Boulder Creek and springs in the vicinity of the U.S. Highway 93 bridge. The chemistry of Burro Creek above Boulder Creek is generally similar to that of Burro Creek below Francis Creek, suggesting a high degree of dependence on the waters of Francis Creek for downstream flow maintenance. Anomalously high sodium and

chloride levels at site BC014 in August may have been the result of spring inflow; in spite of any such inflow, however, Burro Creek between Francis and Boulder Creeks was a losing segment. Flow at all sites was very low in summer, reaching levels ($\leq$ 0.5 cfs) just above those required to maintain surface throughflow in this reach of stream.

2. Boulder Creek exerts effects on Burro Creek chemistry even when surface flow in the former creek is lacking: Increases in sulfate and fluoride concentrations were the most notable results of the inflow of subsurface water to Burro Creek from Boulder Creek. Fluoride concentrations in Burro Creek rose above recommended drinking water limits. The effects of Boulder Creek on Burro Creek were most noticeable in early summer and declined through October, probably in response to decreasing subsurface flow. Copper appeared at several Burro Creek sites downstream of Boulder Creek in August and October, but at levels well below State surface water quality standards and EPA criteria. Copper increases may have been due to mining or to the natural weathering of this highly mineralized area.

3. Metals exports from the Boulder Creek drainage caused slightly elevated concentrations of metals in sediments and frog tissue in samples collected in Burro Creek below the Boulder Creek confluence: Copper, zinc, and possibly other metals were enriched in sediments at site BC013 compared to those collected upstream in Burro Creek at site BC015, apparently due to export from sources along Boulder Creek. With the exception of single high copper concentration (309 mg/kg) at BC013 following high water levels (and presumably high export rates) in January, metal concentrations in Burro Creek

sediments were much lower than those in sediments collected near known heavy metal sources along Boulder Creek. Frog tissue samples collected from BC013 were higher in copper and zinc than those taken in Boulder Creek upstream of the Hillside complex. These levels in Burro Creek frogs were lower than those in frogs taken downstream of the Hillside complex and in the vicinity of Copper Creek, however, indicating a gradual downstream abatement of heavy metal uptake by stream organisms. Those metals most concentrated by Burro Creek frogs (copper and zinc) have low biomagnification potentials. Given this and the apparent vitality of the aquatic communities in Burro Creek downstream of Boulder Creek, the effect of current metal export from Boulder Creek was judged to be insignificant.

4. The USBLM Campground facilities downstream of the U.S. Highway 93 Bridge did not have a measurable effect on the water quality of Burro Creek: Levels of most nutrients, suspended sediments, major ions, and fecal coliform bacteria did not increase in Burro Creek in the vicinity of the USBLM campground. As such, the campground facilities and associated recreational uses were judged to be compatible with maintenance of good instream water quality. High nitrate concentrations in these waters (up to 1.2 mg/l as N), which supported prolific growths of algae and aquatic macrophytes, probably originated in springs located just upstream of the campground and were naturally occurring. Further monitoring of the chemical and microbiological quality of surface and groundwater near the campground seems warranted in view of the potential contaminant source present in the form of campground toilet facilities, instream recreation and

the presence of grazing burros and livestock.

5. Water in this reach of Burro Creek is of less than optimal quality as a drinking water source but is well-suited to all other beneficial uses: Sodium and fluoride exceeded recommended drinking water limits at certain sites during summer. These exceedences were not drastic and, while not desirable, do not compromise the use of Burro Creek as a short-term domestic water source such as for campers, hikers, etc. Burro Creek's waters easily met State surface water quality standards and other recognized criteria for fish and aquatic life protection, livestock watering, agricultural irrigation, and riparian habitat maintenance (Table 1).

OVERVIEW AND OPPORTUNITIES FOR FURTHER STUDY

The water quality of the Burro Creek watershed is highly variable on a seasonal and geographic basis. Francis Creek and Burro Creek in the vicinity of the Francis Creek confluence contain waters of excellent quality, well-suited to all the uses of concern in this study. These waters support vigorous and diverse aquatic habitats and remain a stronghold for native fishes, including the recently State-listed roundtail chub (Gila robusta). Grazing in this area may already affect terrestrial ecology, perpetuating unstable disclimax plant communities on hillsides and mesas, and reducing native riparian canopy replacement (Brown, 1982; Sanchez, 1982). As yet, however, effects on aquatic chemistry have been slight. Of more direct concern is the ability of public and private interests in this area to regulate water withdrawals in Francis Creek, and to insure that downstream flow remains adequate to maintain aquatic and riparian communities in Francis and Burro Creeks. Survey results strongly imply that the existence of vigorous communities in these creeks is dependent not only on the existence of water, but on the existence of flowing water.

Boulder Creek provides examples of the destruction that can result from pollution by uncontained mine wastes, and of the very meaningful water quality improvements to be gained by the proper containment of mine process runoff. Two sources at the abandoned Hillside Mine contribute heavy metals, sulfates, acidity, suspended solids and probably, radioactivity that make up to two miles of the creek unsuitable for any of the aforementioned benefical uses. These effects are particularly severe in summer when seepage from the Hillside forms an important portion of Boulder Creek flow. Rehabilitation of this site will be difficult and expensive; the track record of mine tailings reclamation projects on abandoned sites in Arizona has been poor, although progress in techniques such as lime neutralization and anti-bacterial surfactant use have produced success in other parts of the country

(Lampkin, 1980; Wangen and Williams 1982; U.S. Bureau of Mines, 1983).

The efforts of Cyprus-Bagdad Copper Corporation to minimize Boulder Creek contamination by more effectively containing runoff from their heap leach near the mouth of Copper Creek appear to have met with success. While the chemical quality of surface and shallow groundwater in Copper Creek appears to have improved only slightly as a result of these efforts, inflow from this source has been greatly reduced. As a result, the Boulder Creek aquatic community has made a strong recovery since the late 1970's (Kepner, 1979), and appeared to field personnel to be essentially healthy. The old Cyprus-Bagdad tailings, downstream of Copper Creek, contribute particulate metal loads to Boulder Creek during times of heavy precipitation, but such loads are probably of little ecological significance. Boulder Creek's waters, in areas not sterilized by Hillside mine drainage, are less than acceptable as domestic water sources, primarily due to high concentrations of fluoride, sodium and, at downstream sites, sulfate. Stretches of the creek away from mine drainage provide acceptable aquatic habitat, but the lack of summer throughflow makes the remaining pools less desirable as habitat than flowing reaches of Francis and Burro Creeks.

Boulder Creek has recognizable effects on Burro Creek, raising its levels of sulfate and fluoride. Metals increases in Burro Creek were most notable in sediment and tissue samples. These increases did not appear to adversely affect stream communities; productivity remained high at downstream sites. A USBLM campground alongside the creek below U.S. Highway 93 did not have recognizable effects on instream water quality.

The resource value of the Burro Creek drainage and its fragility in the face of mining, grazing, and water withdrawals dictate that continued monitoring take place in the watershed. A monitoring scheme adequate to provide an indication

of the health of the drainage would include sampling at the following sites:

Francis Creek at mouth (BC031);

Francis Creek near the Cyprus-Bagdad pump (BC035);

Burro Creek below Francis Creek (BC015);

Burro Creek above Boulder Creek (BC014);

Burro Creek below Boulder Creek (BC013);

Burro Creek below USBLM campground (BC010);

Boulder Creek near Butte Creek (BC027);

Boulder Creek near Copper Creek (BC024);

Boulder Creek near mouth (BC021); and

Monitor well near Copper Creek mouth (BC042).

Parameters monitored at these sites should include: discharge, water temperature, pH, conductance, dissolved oxygen, turbidity or total suspended solids, hardness, total dissolved solids, sulfate, total copper and total manganese. Samples collected at site BC010 should additionally be analyzed for fecal coliform bacteria. Sampling need not be as frequent as in the intensive survey. Three non-flood samples per year, one in winter or spring, one in summer, and one in early fall, are suggested. USBLM may wish to consult with Cyprus-Bagdad before initiating monitoring, to determine the extent of that company's ongoing water quality monitoring. A one-time sampling for radiochemical parameters during low flows is also advised, owing to the demonstrated presence of waterborne radioactivity emanating from the Hillside Mine complex.

The Burro Creek watershed provides many opportunities for scientific study. Changes in Boulder Creek water chemistry as it passes sources at the Hillside Mine would provide a challenging real-world example with which to calibrate models of heavy metal behavior in aqueous systems. The same offers opportunities for studies of community recovery downstream of pollution sources, and for tracing

the pathways of a number of heavy metals through the aquatic food web. Innovative pollution control methods, such as surfactant application for the reduction of bacteria in tailings, might be tried at the Hillside. Natural point sources for nitrate exist along Francis, Boulder, and Burro Creeks, allowing in situ nitrogen uptake studies. Francis Creek's thermal springs present an excellent opportunity for the study of the effects of temperature on productivity, the seasonal succession of periphyton, and the reproductive efficiency of native fishes.

Correction of the single most severe water quality problem in the watershed, that of toxic mine drainage from the Hillside complex, will present difficult legal and administrative problems. While the evidence pointing to violations of State surface water quality standards is irrefutable, problems remain in defining ownership and individual liabilities for the violations. Should these issues be resolved, there exists the possibility that the present owners of the property will be unable to pay any monetary penalties levied against them, rendering this type of legal action futile. The applicability of Federal environmental funds to reclamation of the Hillside property is questionable, since mining operations have been exempt from such legal recourse as USEPA's Superfund program. One technical aspect of the problem that USBLM may wish to investigate from a regulatory standpoint is whether or not the presence of waterborne radioactivity at Hillside affects its eligibility under available Federal environmental programs. USBLM may wish to contact the Federal Nuclear Regulatory Agency in this regard. Legal investigations into these issues for the purpose of effecting eventual mitigation of this problem may eventually prove to be as important as continued technical investigations in maintaining the integrity of the drainage.

Burro Creek and its tributaries comprise one of the most valuable water resources in western Arizona. Though some areas are severely stressed by mine drainage and

others face the possibility of long-term degeneration of the riparian community from grazing, large reaches of the creeks are in excellent condition as regards water quality and the aquatic communities they support. They are superb examples of permanent desert streams, increasingly rare, uniquely Southwestern resources. Special management status, such as inclusion in the national wilderness system (USBLM, 1982) or in Arizona's Unique Waters network (AWQCC, 1981), have been proposed for portions of the Burro Creek drainage. Such management actions, including others specified within this report, should be well considered by USBLM and other public and private entities in the watershed. Those alternatives germane to the protection and improvement of the quality of the drainage's water and riparian resources should be adopted in an active management scheme, such as the Burro Creek Riparian Management Area Plan already formulated (USBLM, 1983). The status quo characterized in this report is a delicate one; pressures on the drainage from abandoned mine waste, water withdrawals, and grazing are real, their effects readily observable. Conversely, active management techniques, such as those undertaken by Cyprus-Bagdad, have resulted in notable watershed improvement. Pressure from the three aforementioned sources cannot increase if Burro Creek is to remain a valuable resource. Reduction of these pressures would likely insure Burro Creek's continued place among the State's finest desert streams, an eminently worthwhile goal for any management agency.

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APPENDIX A

Water Quality Data,

Burro Creek Intensive

and

Background Surveys

(Water Quality Data Retrieval

from

USEPA STORET Date Base)

10671000001657 6C010 T14NR11WS19C
34 32 04.0 113 27 13.0 2
BURRO CREEK BELOW CAMPGROUND
04015 ARIZONA MOHAVE
COLORADO RIVER 110100
LOWER COLORADO RIVER
21ARIZ
820306 DEPTH 1
/TYPA/AMBNT/STREAM

INITIAL DATE				82/02/11	82/04/08	82/06/19	82/06/19	82/08/20	82/10/17	82/12/13	83/02/18
INITIAL TIME-DEPTH-BOTTOM				1530 0001	1145 0001	0930	1015 0001	1030 0001	1420 0001	1120	0900
00010	WATER	TEMP	CENT	10.0	16.3		28.5	30.0	22.8	7.3	8.4
00011	WATER	TEMP	FAHN	50.0	61.3		83.3	86.0	73.0	45.1	47.1
00020	AIR	TEMP	CENT		22.0		35.0	35.0	25.0	20.0	12.0
00061	STREAM	FLOW,	INST-CFS			1		1	1	132	
00094	CNDUCTVY	FIELD	MICROMHO	122	470		590	810	590	300	360
00095	CNDUCTVY	AT 25C	MICROMHO	164	498		571	568	578	311	311
00116	INTNSVE	SURVEY	IDENT	820401	820401		820401	820401	820401		
00300	DO		MG/L	10.0	11.7		7.1	9.9	14.8	12.4	11.0
00301	DO	SATUR	PERCENT	88.5	117.0		91.0	130.3	170.1	101.6	92.4
00400	PH		SU	7.70	8.40		8.60	8.10	8.62	8.12	8.41
00403	LAB	PH	SU	7.3	8.5		8.5	8.7	9.0	7.8	7.9
00410	T ALK	CACO3	MG/L	58	127		126	116	108	81	91
00415	PHEN-PH-	LFIN ALK	MG/L	0	2		5	7	10	0	0
00500	RESIDUE	TOTAL	MG/L	280	300		355	397	341	204	224
00530	RESIDUE	TOT NFLT	MG/L		2		1	1 K	3	11	2
00625	TOT KJEL	N	MG/L	0.200 K	16.000			0.270	0.620	0.780	0.800
00665	PHOS-TOT		MG/L P	0.280	0.050		0.050 K	0.490	0.050 K	0.050 K	0.060
00671	PHOS-DIS	ORTHO	MG/L P				0.015	0.220	0.010 K	0.050	0.050
00900	TOT HARD	CACO3	MG/L	82	150		166	166	162	100	114
00916	CALCIUM	CA-TOT	MG/L	24.0	41.0		42.0	32.8	34.0	26.0	32.0
00927	MGNSIUM	MG,TOT	MG/L	5.0	12.0		14.0	20.3	18.0	8.0	8.0
00929	SODIUM	NA,TOT	MG/L	7.00	36.00		54.00	58.00	53.80	21.70	24.30
00935	PTSSIUM	K,DISS	MG/L					10.00			
00937	PTSSIUM	K,TOT	MG/L	4.00	6.30		9.00	9.90	8.70	4.00	4.20
00940	CHLORIDE	TOTAL	MG/L	4	20		45	54	53	9	10
00945	SULFATE	SO4-TOT	MG/L	32	54		74	70	62	27	28
00951	FLUORIDE	F,TOTAL	MG/L	0.28	1.04		1.05	1.16	1.15	0.67	0.70
01000	ARSENIC	AS,DISS	UG/L	20 K	20 K		20 K	20 K	20 K	20 K	20 K
01002	ARSENIC	AS,TOT	UG/L	20 K	20 K		20 K	22	20 K	20 K	20 K
01022	BORON	B,TOT	UG/L		29						
01025	CADMIUM	CD,DISS	UG/L	5 K	5 K		5 K	5 K	5 K	5 K	5 K
01027	CADMIUM	CD,TOT	UG/L	5 K	5 K		5 K	5 K	5 K	5 K	5 K
01030	CHROMIUM	CR,DISS	UG/L	50 K	50 K		10 K	10 K	10 K	10 K	10 K
01034	CHROMIUM	CR,TOT	UG/L	80 K	50 K		10 K	10 K	10 K	10 K	10 K
01040	COPPER	CU,DISS	UG/L	50 K	50 K			10 K	10 K	10 K	10
01042	COPPER	CU,TOT	UG/L	150	50 K		50 K	20 K	11	27	10 K
01045	IRON	FE,TOT	UG/L	1730	50 K		100 K	100 K	100 K	1340	310
01046	IRON	FE,DISS	UG/L	50 K	50 K			100 K	100 K	330	100
01049	LEAD	PB,DISS	UG/L	20 K	20 K		20 K	20 K	20 K	20 K	20 K
01051	LEAD	PB,TOT	UG/L	20 K	20 K		20 K	20 K	20 K	20 K	20 K
01055	MANGNESE	MN	UG/L	1210.0	50.0 K		50.0 K	50.0 K	50.0 K	50.0 K	50.0 K
01056	MANGNESE	MN,DISS	UG/L	50.0 K	50.0			50.0 K	50.0 K	50.0 K	50.0 K
01060	MOLY	MO,DISS	UG/L	10 K	13		16	14	13	10 K	10 K
01062	MOLY	MO,TOT	UG/L	10 K	10 K		15	10 K	10 K	24	10 K
01075	SILVER	AG,DISS	UG/L	50.0 K	50.0		5.0 K	5.0 K	50.0 K	5.0 K	5.0 K

(SAMPLE CONTINUED ON NEXT PAGE)

10671000001657 BC010 T14NR11WS19C
34 32 04.0 113 27 13.0 2
BURRO CREEK BELOW CAMPGROUND
04015 ARIZONA MOHAVE
COLORADO RIVER 110100
LOWER COLORADO RIVER
21ARIZ
820306 DEPTH 1
/TYPA/AMBNT/STREAM

(SAMPLE CONTINUED FROM PREVIOUS PAGE)

				INITIAL DATE	82/02/11	82/04/08	82/06/19	82/06/19	82/08/20	82/10/17	82/12/13	83/02/18
				INITIAL TIME-DEPTH-BOTTOM	1530 0001	1145 0001	0930	1015 0001	1030 0001	1420 0001	1120	0900
01077	SILVER	AG,TOT	UG/L		50.0 K	50.0 K		5.0 K	5.0 K	5.0 K	5.0 K	5.0 K
01090	ZINC	ZN,DISS	UG/L		50 K	50 K			50 K	50 K	50 K	50 K
01092	ZINC	ZN,TOT	UG/L		140	50 K		50 K	50 K	50 K	50 K	50 K
01095	ANTIMONY	SB,DISS	UG/L		10 K	10 K		10 K	15	10 K	10 K	10 K
01097	ANTIMONY	SB,TOT	UG/L		10 K	10 K		10 K	12	10 K	10 K	10 K
01145	SELENIUM	SE,DISS	UG/L		5 K	5 K		5 K	5 K	5 K	5 K	5 K
01147	SELENIUM	SE,TOT	UG/L		5 K	5 K		5 K	5 K	5 K	5 K	5 K
31613	FEC COLI	M-FCAGAR	/100ML								7	2 K
31625	FEC COLI	M-FCAGAD	/100 ML			2 K			12	2		
71850	NITRATE	TOT-NO3	MG/L		2.2	0.1		1.4	0.4	2.3	0.6	0.4
71890	MERCURY	HG,DISS	UG/L		2.0 K	0.5 K		0.5 K	0.5 K	0.5 K	0.5 K	0.5 K
71900	MERCURY	HG,TOTAL	UG/L		2.0 K	0.5 K		0.5 K	0.5 K	0.5 K	0.5 K	0.5 K
82079	TURBIDTY	LAB	NTU		580.0	2.0		2.0	1.0	0.7	22.0	8.7
82233	SILICON	SI TOTAL	MG/L			12.60		10.20	17.00	13.90	18.00	13.40

106710000001707 BC011
34 32 19.0 113 27 01.0 2
BURRO CREEK ABOVE BLM C-G
04005 ARIZONA COCONINO
COLORADO RIVER 110100
LOWER COLORADO RIVER
21ARIZ
830205 DEPTH 1
/TYPA/AMBNT/STREAM

INITIAL DATE				82/04/08	82/06/19	82/08/20	82/10/17	82/10/17	82/12/13	83/02/18
INITIAL TIME-DEPTH-BOTTOM				1115 0001	0930 0001	1000 0001	0000	0001	1020	0830
00010	WATER	TEMP	CENT	14.5	26.0	30.0		22.0	7.0	8.2
00011	WATER	TEMP	FAHN	58.1	78.8	86.0		71.6	44.6	46.8
00020	AIR	TEMP	CENT	22.0	32.0	35.0		25.0	18.0	12.0
00094	CNDUCTVY	FIELD	MICROMHO	460	590	810		620	290	340
00095	CNDUCTVY	AT 25C	MICROMHO	500	589	598		584	311	310
00116	INTNSVE	SURVEY	IDENT	820401	820401	820401	820401			
00300	DO		MG/L	12.2	7.4	9.8		13.2	11.3	110.0
00301	DO	SATUR	PERCENT	119.6	90.2	128.9		150.0	92.6	924.4
00400	PH		SU	8.40	8.20	8.10		8.62	8.27	8.34
00403	LAB	PH	SU	8.4	8.5	8.2		8.9	7.8	7.9
00410	T ALK	CACO3	MG/L	129	133	126		113	78	89
00415	PHEN-PH-	LPIN ALK	MG/L	2	5	0		10	0	0
00500	RESIDUE	TOTAL	MG/L	293	374	520		350	187	216
00530	RESIDUE	TOT NFLT	MG/L	2	1 K	1 K		3	10	1 K
00625	TOT KJEL	N	MG/L	18.000	0.200	0.100 K		0.740	0.780	0.800
00665	PHOS-TOT		MG/L P	0.050 K	0.050	0.470		0.050 K	0.050	0.060
00671	PHOS-DIS	ORTHO	MG/L P	0.010 K	0.010	0.260		0.010 K		0.060
00900	TOT HARD	CACO3	MG/L	152	178	178		164	96	114
00916	CALCIUM	CA-TOT	MG/L	38.0	42.0	35.5		36.0	26.0	32.0
00927	MGNSIUM	MG,TOT	MG/L	13.0	18.0	21.6		18.0	7.0	8.0
00929	SODIUM	NA,TOT	MG/L	37.00	53.00	57.00		51.10	21.20	24.30
00935	PTSSIUM	K,DISS	MG/L	6.10		10.10				
00937	PTSSIUM	K,TOT	MG/L	5.40	9.00	10.00		8.40	3.90	4.30
00940	CHLORIDE	TOTAL	MG/L	21	46	54		53	9	11
00945	SULFATE	SO4-TOT	MG/L	55	67	66		61	26	29
00951	FLUORIDE	F,TOTAL	MG/L	1.12	1.09	1.18		1.16	0.66	0.70
01000	ARSENIC	AS,DISS	UG/L	20 K	20 K	20 K		20 K	20 K	20 K
01002	ARSENIC	AS,TOT	UG/L	20 K	20 K	20 K		20 K		20 K
01025	CADMIUM	CD,DISS	UG/L	5 K	5 K	5 K		5 K	5 K	5 K
01027	CADMIUM	CD,TOT	UG/L	5 K	5 K	5		5 K		5 K
01030	CHROMIUM	CR,DISS	UG/L	50 K	10 K	10 K		10 K	10 K	10 K
01034	CHROMIUM	CR,TOT	UG/L	50 K	10 K	10 K		10 K		10 K
01040	COPPER	CU,DISS	UG/L	50 K		10 K		10 K	10 K	10 K
01042	COPPER	CU,TOT	UG/L	50 K	50 K	15		13	25	10 K
01045	IRON	FE,TOT	UG/L	50 K	100 K	100 K		100 K	1340	340
01046	IRON	FE,DISS	UG/L	50 K		100 K		100 K	130	100
01049	LEAD	PB,DISS	UG/L	20 K	20 K	20 K		20 K	20 K	20 K
01051	LEAD	PB,TOT	UG/L	20 K	20 K	20 K		20 K		20 K
01054	MANGNESE	MN,SUSP	UG/L	50.0 K						
01055	MANGNESE	MN	UG/L		50.0 K	50.0 K		50.0 K	50.0 K	50.0 K
01056	MANGNESE	MN,DISS	UG/L	50.0 K		50.0 K		50.0 K	50.0 K	50.0 K
01060	MOLY	MO,DISS	UG/L	13	13	11		15	10 K	10 K
01062	MOLY	MO,TOT	UG/L	17	10 K	18		10 K	10 K	10 K
01075	SILVER	AG,DISS	UG/L	50.0 K	5.0 K	5.0 K		5.0 K	5.0 K	5.0 K
01077	SILVER	AG,TOT	UG/L	50.0 K	5.0 K	5.0 K		5.0 K		5.0 K

(SAMPLE CONTINUED ON NEXT PAGE)

106710000001707 BC011
34 32 19.0 113 27 01.0 2
BUBBO CREEK ABOVE BLM C-G
04005 ARIZONA COCONINO
COLORADO RIVER 110100
LOWER COLORADO RIVER
21ARIZ
830205 DEPTH 1
/TYPA/AMBNT/STREAM

(SAMPLE CONTINUED FROM PREVIOUS PAGE)

	INITIAL DATE			82/04/08	82/06/19	82/08/20	82/10/17	82/10/17	82/12/13	83/02/18	
	INITIAL TIME-DEPTH-BOTTOM			1115 0001	0930 0001	1000 0001	0000	0001	1020	0830	
01090	ZINC	ZN,DISS	UG/L	50 K		50 K		50 K	50 K	50 K	
01092	ZINC	ZN,TOT	UG/L	50 K	50 K	50 K		50 K	50 K	50 K	
01095	ANTIMONY	SB,DISS	UG/L	10 K	10 K	11		10 K	10 K	10 K	
01097	ANTIMONY	SB,TOT	UG/L	10 K	10 K	10 K		10 K	10 K	10 K	
01145	SELENIUM	SE,DISS	UG/L	5 K	5 K	5 K		5 K	5 K	5 K	
01147	SELENIUM	SE,TOT	UG/L	5	5 K	5 K		5 K		5 K	
31613	FEC COLI	M-FCAGAR	/100ML						20	2 K	
31625	FEC COLI	M-FCAGAD	/100 ML	2 K	6	40		4			
71850	NITRATE	TOT-NO3	MG/L	0.2	3.5	2.0		5.5	0.6	0.4 K	
71890	MERCURY	HG,DISS	UG/L	0.5 K	0.5 K	0.5 K		0.5 K	0.5 K	0.5 K	
71900	MERCURY	HG,TOTAL	UG/L	0.5	0.5 K	0.5 K		0.5 K		0.5 K	
82079	TURBIDTY	LAB	NTU	2.0	2.0	1.0		1.0	22.0	9.5	
82233	SILICON	SI TOTAL	MG/L	12.10	12.00	19.60		17.70	18.80	14.00	

STORET RETRIEVAL DATE 83/09/09
10671000000425O BC013 T15NR10WS28B
34 37 03.0 113 18 42.0 2
BURRO CR BELOW BOULDER CR
04025 ARIZONA YAVAPAI
COLORADO RIVER 110100
LOWER COLORADO RIVER
21ARIZ
820227 DEPTH 1
/TYPA/AMBNT/STREAM

	INITIAL DATE			82/02/11		82/04/07		82/06/18		82/08/19		82/10/16	82/12/11	83/02/17
	INITIAL TIME-DEPTH-BOTTOM			1100 0001		1345 0001		1300 0001		1300 0001		1650 0001	1400	1315
00010	WATER	TEMP	CENT	7.5		18.0		28.0		30.0		20.9	8.8	12.0
00011	WATER	TEMP	FAHN	45.5		64.4		82.4		86.0		69.6	47.8	53.6
00020	AIR	TEMP	CENT			20.0		35.0		45.0		25.0	22.0	20.0
00061	STREAM	FLOW,	INST-CFS							0				
00094	CNDUCTVY	FIELD	MICROMHO	95		410				1100		380	140	290
00095	CNDUCTVY	AT 25C	MICROMHO	127		463		662		781		586	159	333
00116	INTNSVE	SURVEY	IDENT	820401		820401		820401		820401		820401		
00300	DO		MG/L	11.0		9.1		9.2		9.4		13.7	12.2	11.9
00301	DO	SATUR	PERCENT	92.4		95.8		116.5		123.7		152.2	105.2	110.2
00400	PH		SU	7.40		8.60		8.30		8.20		8.28	7.43	8.58
00403	LAB	PH	SU	7.2		8.3		7.9		8.1		8.6	7.6	8.0
00410	T ALK	CACO3	MG/L	44		125		152		219		161	45	81
00415	PHEN-PH-	LFIN ALK	MG/L	0		0		0		0		5	0	0
00500	RESIDUE	TOTAL	MG/L	440		285		452		538		345	126	221
00530	RESIDUE	TOT NFLT	MG/L	1250		1	K	1		1		5	59	2
00625	TOT KJEL	N	MG/L	0.200	K	2.000	K	0.270		0.760		0.780	1.000	0.700
00665	PHOS-TOT		MG/L P	0.150		0.060		0.050	K	0.070		0.050 K	0.050 K	0.060
00671	PHOS-DIS	ORTHO	MG/L P			0.026		0.010	K	0.280		0.010 K	0.100	6.000
00900	TOT HARD	CACO3	MG/L	62		142		244		233		172	56	108
00916	CALCIUM	CA-TOT	MG/L	21.0		38.0		61.0		49.6		39.0	17.0	29.0
00927	MGNSIUM	MG,TOT	MG/L	2.0		12.0		22.0		26.4		18.0	3.0	9.0
00929	SODIUM	NA,TOT	MG/L	5.00		28.00		53.00		89.00		57.20	10.00 K	18.00
00935	PTSSIUM	K,DISS	MG/L							10.40				
00937	PTSSIUM	K,TOT	MG/L	3.00		5.30		8.00		10.30		7.60	3.30	3.70
00940	CHLORIDE	TOTAL	MG/L	3		13		29		51		28	2	8
00945	SULFATE	SO4-TOT	MG/L	31		41		127		79		48	18	23
00951	FLUORIDE	F,TOTAL	MG/L	0.24		0.97		1.51		1.50		0.94	0.33	0.60
01000	ARSENIC	AS,DISS	UG/L	20	K	20	K	20	K	24		20 K	20 K	20 K
01002	ARSENIC	AS,TOT	UG/L	20	K	20	K	20	K	30		20 K	20 K	20 K
01025	CADMIUM	CD,DISS	UG/L	5	K	5	K	5	K	5	K	5 K	5 K	5 K
01027	CADMIUM	CD,TOT	UG/L	5	K	5	K	5	K	5	K	5 K	5 K	5 K
01030	CHROMIUM	CR,DISS	UG/L	50	K	50	K	10	K	10	K	10 K	10 K	10 K
01034	CHROMIUM	CR,TOT	UG/L	90	K	50	K	10	K	10	K	10 K	10 K	10 K
01040	COPPER	CU,DISS	UG/L	50	K	50	K			10	K	10 K	10 K	10 K
01042	COPPER	CU,TOT	UG/L	70		50	K	50	K	10	K	12	27	10 K
01045	IRON	FE,TOT	UG/L	1530		50	K	100	K	100	K	140	4650	630
01046	IRON	FE,DISS	UG/L	240		50	K			100	K	100 K	130	290
01049	LEAD	PB,DISS	UG/L	20	K	20	K	20	K	20	K	20 K	20 K	20 K
01051	LEAD	PB,TOT	UG/L	20	K	20	K	20	K	20	K	20 K	20 K	20 K
01055	MANGNESE	MN	UG/L	1020.0		50.0	K	50.0	K	50.0	K	50.0 K	80.0	50.0 K
01056	MANGNESE	MN,DISS	UG/L	50.0	K	50.0	K			50.0	K	50.0 K	50.0 K	50.0 K
01060	MOLY	MO,DISS	UG/L	10	K	11		10	K	10	K	10	10 K	10 K
01062	MOLY	MO,TOT	UG/L	10	K	10	K	10	K	19		10	10 K	10 K
01075	SILVER	AG,DISS	UG/L	50.0	K	50.0	K	5.0	K	5.0	K	5.0 K	5.0 K	5.0 K
01077	SILVER	AG,TOT	UG/L	50.0	K	50.0	K	5.0	K	5.0	K	5.0 K	5.0 K	5.0 K

(SAMPLE CONTINUED ON NEXT PAGE)

10671000000004250 BC013 T15NR10WS28B
34 37 03.0 113 16 42.0 2
BORRO CR BELOW BOULDER CR
04025 ARIZONA YAVAPAI
COLORADO RIVER 110100
LOWER COLORADO RIVER
21ARIZ
820227 DEPTH 1
/TYPA/AMBNT/STREAM

(SAMPLE CONTINUED FROM PREVIOUS PAGE)

				INITIAL DATE	82/02/11	82/04/07	82/06/18	82/08/19	82/10/16	82/12/11	83/02/17
				INITIAL TIME-DEPTH-BOTTOM	1100 0001	1345 0001	1300 0001	1300 0001	1650 0001	1400	1315
01090	ZINC	ZN,DISS	UG/L		50 K	50 K		50 K	50 K	100	50 K
01092	ZINC	ZN,TOT	UG/L		110	50 K	50 K	50 K	50 K	50 K	50 K
01095	ANTIMONY	SB,DISS	UG/L		10 K	10 K	10 K	13	10 K	10 K	10 K
01097	ANTIMONY	SB,TOT	UG/L		10 K	10 K	10 K	10 K	10	10 K	10 K
01145	SELENIUM	SE,DISS	UG/L		5 K	5 K	5 K	5 K	5 K	5 K	5 K
01147	SELENIUM	SE,TOT	UG/L		5 K	5 K	5 K	5 K	5 K	5 K	5 K
01501	ALPHA	TOTAL	PC/L								2 K
03501	BETA	TOTAL	PC/L								3 K
22708	U-NAT	TOTAL	MG/L								0.001 K
31613	FEC COLI	M-FCAGAR	/100ML							100	3
31625	FEC COLI	M-FCAGAD	/100 ML			2 K	12	1 K	8		
71850	NITRATE	TOT-NO3	MG/L		2.1	0.1	0.2	0.2 K	0.2	0.5	0.4 K
71890	MERCURY	HG,DISS	UG/L		2.0 K	0.5 K	0.5 K	0.5 K	0.5 K	0.5 K	0.5 K
71900	MERCURY	HG,TOTAL	UG/L		2.0 K	0.5 K	0.5 K	0.5 K	0.5 K	0.5 K	0.5 K
82079	TURBIDTY	LAB	NTU		460.0	3.0	2.0	2.0	3.0	44.0	14.0
82233	SILICON	SI TOTAL	MG/L			14.60	12.00	17.00	14.30	27.50	15.80

106710000004345 BC014
34 37 06.0 113 18 08.0 2
BURRO CREEK AT OLD PUMPHOUSE
04025 ARIZONA YAVAPAI
COLORADO RIVER 110100
LOWER COLORADO RIVER
21ARIZ
830205 DEPTH 1
/TYPA/AMBNT/STREAM

INITIAL DATE				82/04/07	82/06/18	82/08/19	82/10/16	82/10/16	82/12/11	83/02/17
INITIAL TIME-DEPTH-BOTTOM				1130 0001	1100 0001	1200 0001	1500 0001	1505	1120	1115
00010	WATER	TEMP	CENT	15.0	26.5	30.0	19.8		7.0	8.0
00011	WATER	TEMP	FAHN	59.0	79.7	86.0	67.6		44.6	46.4
00020	AIR	TEMP	CENT	19.0	35.0	36.0	25.0		20.0	19.5
00061	STREAM	FLOW,	INST-CFS	14	0	1		1		41
00094	CNDUCTVY	FIELD	MICROMHO	355	425	1070	485		142	300
00095	CNDUCTVY	AT 25C	MICROMHO	398	422	763	465		159	272
00116	INTNSVE	SURVEY	IDENT	820401	820401	820401	820401			
00300	DO		MG/L	10.1	9.2	9.2	12.2		12.8	11.3
00301	DO	SATUR	PERCENT	99.0	113.6	121.1	132.6		104.9	95.0
00400	PH		SU	8.70	8.40	8.60	8.51			8.83
00403	LAB	PH	SU	8.4	8.2	8.4	8.7		7.7	7.9
00410	T ALK	CACO3	MG/L	138	156	252	161		52	89
00415	PHEN-PH-	LFIN ALK	MG/L	2	0	4	5		0	0
00500	RESIDUE	TOTAL	MG/L	224	266	456	278		126	201
00530	RESIDUE	TOT NFLT	MG/L	1 K	2	4	2		62	1 K
00625	TOT KJEL	N	MG/L	0.200 K		0.600	0.460		1.600	1.200
00665	PHOS-TOT		MG/L P	0.050 K	0.050 K	0.680	0.050 K		0.050 K	0.080
00671	PHOS-DIS	ORTHO	MG/L P	0.016	0.010	0.310	0.010 K		0.110	0.060
00900	TOT HARD	CACO3	MG/L	124	124	173	136		56	96
00916	CALCIUM	CA-TOT	MG/L	42.0	27.0	33.8	35.0		16.0	25.0
00927	MGNSIUM	MG,TOT	MG/L	4.0	13.0	21.5	12.0		4.0	8.0
00929	SODIUM	NA,TOT	MG/L	26.00	42.00	109.00	48.40		10.00 K	16.30
00935	PTSSIUM	K,DISS	MG/L			12.60				
00937	PTSSIUM	K,TOT	MG/L	5.70	0.41	12.70	7.50		3.60	4.10
00940	CHLORIDE	TOTAL	MG/L	12	20	56	23		2	7
00945	SULFATE	SO4-TOT	MG/L	11	12	32	13		17	11
00951	FLUORIDE	F,TOTAL	MG/L	0.33	0.46	0.74	0.49		0.20	0.25
01000	ARSENIC	AS,DISS	UG/L	20 K	20 K	34	20 K		20 K	20 K
01002	ARSENIC	AS,TOT	UG/L	20 K	20 K	0 K	20 K		20 K	20 K
01025	CADMIUM	CD,DISS	UG/L	5 K	5 K	5 K	5 K		5 K	5 K
01027	CADMIUM	CD,TOT	UG/L	5 K	5 K	5 K	5 K		5 K	5 K
01030	CHROMIUM	CR,DISS	UG/L	50 K	10 K	10 K	10 K		10 K	10 K
01034	CHROMIUM	CR,TOT	UG/L	50 K	10 K	10 K	10 K		10 K	10 K
01040	COPPER	CU,DISS	UG/L	50 K		10 K	10 K		10 K	10 K
01042	COPPER	CU,TOT	UG/L	50 K	50 K	10 K	16		87	10 K
01045	IRON	FE,TOT	UG/L	50 K	100 K	0	100 K		4650	800
01046	IRON	FE,DISS	UG/L	50 K		100 K	100 K		260	340
01049	LEAD	PB,DISS	UG/L	20 K	20 K	20 K	20 K		20 K	20 K
01051	LEAD	PB,TOT	UG/L	20 K	20 K	20 K	20 K		20 K	20 K
01055	MANGNESE	MN	UG/L	50.0 K	50.0 K	50.0 K	50.0 K		50.0	50.0 K
01056	MANGNESE	MN,DISS	UG/L	50.0 K		50.0 K	50.0 K		50.0 K	50.0 K
01060	MOLY	MO,DISS	UG/L	10 K	10 K	10 K	10 K		10 K	10 K
01062	MOLY	MO,TOT	UG/L	12	10 K	11	10 K		10 K	10 K
01075	SILVER	AG,DISS	UG/L	50.0 K	5.0 K	5.0 K	5.0 K		5.0 K	5.0 K
01077	SILVER	AG,TOT	UG/L	50.0 K	5.0 K	5.0 K	5.0 K		5.0 K	5.0 K

(SAMPLE CONTINUED ON NEXT PAGE)

STORET RETRIEVAL DATE 83/09/09
106710000004345 BC014
34 37 06.0 113 18 08.0 2
BURRO CREEK AT OLD PUMPHOUSE
04025 ARIZONA YAVAPAI
COLORADO RIVER 110100
LOWER COLORADO RIVER
21AHIZ
830205 DEPTH 1
/TYPA/AMBNT/STREAM

(SAMPLE CONTINUED FROM PREVIOUS PAGE)

				INITIAL DATE	82/04/07	82/06/18	82/08/19	82/10/16	82/10/16	82/12/11	83/02/17
				INITIAL TIME-DEPTH-BOTTOM	1130 0001	1100 0001	1200 0001	1500 0001	1505	1120	1115
01090	ZINC	ZN,DISS	UG/L		50 K		50 K	50 K		50 K	50 K
01092	ZINC	ZN,TOT	UG/L		50 K	50 K	50 K	50 K		50 K	50 K
01095	ANTIMONY	SB,DISS	UG/L		10 K	10 K	10	10 K		10 K	10 K
01097	ANTIMONY	SB,TOT	UG/L		10 K	10 K	10 K	10 K		10 K	10 K
01145	SELENIUM	SE,DISS	UG/L		5 K	5 K	5 K	5 K		5 K	5 K
01147	SELENIUM	SE,TOT	UG/L		5 K	5 K	5 K	5 K		5 K	5 K
01501	ALPHA	TOTAL	PC/L								2 K
03501	BETA	TOTAL	PC/L								3 K
22708	U-NAT	TOTAL	MG/L								0.005
31613	FEC COLI	M-FCAGAR	/100ML							210	3
31625	FEC COLI	M-FCAGAD	/100 ML		2 K	2	10	6			
71850	NITRATE	TOT-NO3	MG/L		0.2	0.2	0.2 K	0.4 K		0.7	0.4 K
71890	MERCURY	HG,DISS	UG/L		0.5 K	5.0 K	0.5 K	0.5 K		0.5 K	0.5 K
71900	MERCURY	HG,TOTAL	UG/L		0.5 K	0.5 K	0.5 K	0.5 K		0.5 K	0.5
82079	TURBIDTY	LAB	NTU		3.0*	2.0	3.0	1.5		46.0	10.0
82233	SILICON	SI TOTAL	MG/L		17.10	13.70	19.10	14.30		29.00	18.10

10671000000614O BC015 T16NR9WS18BA
34 44 02.0 113 14 40.0 2
BURRO CREEK BELOW FRANCIS CREEK
04025 ARIZONA YAVAPAI
COLORADO RIVER 110100
LOWER COLORADO RIVER
21ARIZ
820227 DEPTH 1
/TYPA/AMBNT/STREAM

INITIAL DATE				82/02/09	82/04/05	82/06/16	82/08/17	82/10/14	82/10/15	82/12/14	83/02/15
INITIAL TIME-DEPTH-BOTTOM				1545 0001	1500 0001	1430 0001	1400 0001	1500 0001	1500	1320	1500
00010	WATER	TEMP	CENT	9.0	16.5	28.0	29.0	18.2		6.8	9.2
00011	WATER	TEMP	FAHN	48.2	61.7	82.4	84.2	64.8		44.2	48.6
00020	AIR	TEMP	CENT		20.0	35.0	31.0	25.0		18.0	18.0
00061	STREAM	FLOW,	INST-CFS	6	13	2	2		2	24	
00094	CNDUCTVY	FIELD	MICROMHO	410	298	350		375		290	191
00095	CNDUCTVY	AT 25C	MICROMHO	389	290	369	333	372		288	210
00116	INTNSVE	SURVEY	IDENT	820401	820401	820401	820401	820401			
00300	DO		MG/L	13.2	10.8	12.9	10.9	14.0		14.4	10.6
00301	DO	SATUR	PERCENT	113.8	111.3	163.3	139.7	147.4		118.0	91.4
00400	PH		SU	8.60	8.80	8.80	9.10	8.80		8.52	8.23
00403	LAB	PH	SU	8.6	8.8	8.9	8.7	8.7		8.0	7.8
00410	T ALK	CACO3	MG/L	176	116	133	128	128		95	66
00415	PHEN-PH-	LPIN ALK	MG/L	12	0	11	9	7		0	0
00500	RESIDUE	TOTAL	MG/L	271	188	245	282	246		171	366
00530	RESIDUE	TOT NFLT	MG/L	5	1 K	3	1 K	2		2	1 K
00615	NO2-N	TOTAL	MG/L			0.010 K					
00625	TOT KJEL	N	MG/L	0.200 K	0.200 K	0.660	0.500	0.940		0.700	0.800
00665	PHOS-TOT		MG/L P	0.030 K	0.040	0.050 K	0.820	0.050 K		0.070	0.100
00671	PHOS-DIS	ORTHO	MG/L P			0.030	0.410	0.010 K		0.050	0.080
00900	TOT HARD	CACO3	MG/L	146	108	124	121	132		102	80
00916	CALCIUM	CA-TOT	MG/L	42.0	34.0	32.0	26.7	32.0		27.0	20.0
00927	MGNSIUM	MG,TOT	MG/L	10.0	5.0	11.0	13.3	12.0		8.0	7.0
00929	SODIUM	NA,TOT	MG/L	28.00	16.00	22.00	24.00	23.30		16.40	10.00
00937	PTSSIUM	K,TOT	MG/L	5.00	4.60	6.00	7.20	6.40		3.70	3.10
00940	CHLORIDE	TOTAL	MG/L	15	8	14	14	15		7	4
00945	SULFATE	SO4-TOT	MG/L	10	9	6	9	11		11	13
00951	FLUORIDE	F,TOTAL	MG/L	0.33	0.22	0.33	0.34	0.30		0.28	0.19
01000	ARSENIC	AS,DISS	UG/L	20 K	20 K	20 K	20 K	20 K		20 K	20 K
01002	ARSENIC	AS,TOT	UG/L	20 K	20 K	20 K	20 K	20 K		20 K	20 K
01025	CADMIUM	CD,DISS	UG/L	5 K	5 K	5 K	5 K	5 K		5 K	5 K
01027	CADMIUM	CD,TOT	UG/L	5 K	5 K	5 K	5 K	5 K		5 K	5 K
01030	CHROMIUM	CR,DISS	UG/L	50 K	50 K	10 K	10 K	10 K		10 K	10 K
01034	CHROMIUM	CR,TOT	UG/L	50 K	50 K	10 K	10 K	10 K		10 K	10 K
01040	COPPER	CU,DISS	UG/L	50 K	50 K	50 K	10 K	10 K		10 K	10 K
01042	COPPER	CU,TOT	UG/L	50 K	50 K	50 K	10 K	10 K		10 K	10 K
01045	IRON	FE,TOT	UG/L	80	50 K	100 K	30 K	100 K		330	2200
01046	IRON	FE,DISS	UG/L	60	50 K	100 K	100 K	100 K		100 K	1070
01049	LEAD	PB,DISS	UG/L	20 K	20 K	20 K	20 K	20 K		20 K	20 K
01051	LEAD	PB,TOT	UG/L	20 K	20 K	20 K	20 K	20 K		20 K	20 K
01055	MANGNESE	MN	UG/L	50.0 K	50.0 K	50.0 K	50.0 K	50.0 K		50.0 K	50.0 K
01056	MANGNESE	MN,DISS	UG/L	50.0 K	50.0 K	50.0 K	50.0 K	50.0 K		50.0 K	50.0 K
01060	MOLY	MO,DISS	UG/L		10 K	10 K	10 K	10 K		10 K	10 K
01062	MOLY	MO,TOT	UG/L	10 K	10 K	29	10 K	10 K		10 K	10 K
01075	SILVER	AG,DISS	UG/L	50.0 K	50.0 K	5.0 K	5.0 K	5.0 K		5.0 K	5.0 K
01077	SILVER	AG,TOT	UG/L	50.0 K	50.0 K	5.0 K	5.0 K	5.0 K		5.0 K	5.0 K

(SAMPLE CONTINUED ON NEXT PAGE)

106710000006140 BC015 T16NR9WS18BA
34 44 02.0 113 14 40.0 2
BURRO CREEK BELOW FRANCIS CREEK
04025 ARIZONA YAVAPAI
COLORADO RIVER 110100
LOWER COLORADO RIVER
21ARIZ
820227 DEPTH 1
/TYPA/AMBNT/STREAM

(SAMPLE CONTINUED FROM PREVIOUS PAGE)

				82/02/09	82/04/05	82/06/16	82/08/17	82/10/14	82/10/15	82/12/14	83/02/15
INITIAL DATE											
INITIAL TIME-DEPTH-BOTTOM				1545 0001	1500 0001	1430 0001	1400 0001	1500 0001	1500	1320	1500
01090	ZINC	ZN,DISS	UG/L	50 K	50 K	50 K	50 K	50 K		50 K	50 K
01092	ZINC	ZN,TOT	UG/L	50 K	50 K	50 K	50 K	50 K		50 K	50 K
01095	ANTIMONY	SB,DISS	UG/L	10 K	10 K	10 K	10 K	10 K		10 K	10 K
01097	ANTIMONY	SB,TOT	UG/L	10 K	10 K	10 K	10 K	10 K		10 K	10 K
01145	SELENIUM	SE,DISS	UG/L	5 K	5 K	5 K	5 K	5 K		5 K	5 K
01147	SELENIUM	SE,TOT	UG/L	5 K	5 K	5 K	5 K	5 K		5 K	5 K
31613	FEC COLI	M-FCAGAR	/100ML							5 K	3
31625	FEC COLI	M-FCAGAD	/100 ML	2 K	6	2	12	5			
71850	NITRATE	TOT-NO3	MG/L	0.4	0.2	0.0	0.2	0.1		0.7	0.6
71890	MERCURY	HG,DISS	UG/L	2.0 K	0.5 K	0.5 K	0.5 K	0.5 K		0.5 K	0.5 K
71900	MERCURY	HG,TOTAL	UG/L	2.0 K	0.5 K	0.5 K	0.5 K	0.5 K		0.5 K	0.5 K
82079	TURBIDTY	LAB	NTU	1.0	2.0	3.0	2.0	0.7		7.0	22.0
82233	SILICON	SI TOTAL	MG/L		18.40	28.10	34.80	30.20		19.80	16.90

STORET RETRIEVAL DATE 83/09/09
10671000000623 6 BC017 T16NR9WS7DB
34 44 30.0 113 14 30.0 2
BURRO CREEK ABOVE FRANCIS CREEK
04025 ARIZONA YAVAPAI
COLORADO RIVER 110100
LOWER COLORADO RIVER
21ARIZ
820227 DEPTH 1
/TYPA/AMBNT/STREAM

	INITIAL DATE			82/02/09	82/04/05	82/06/16	82/08/17	82/10/14	82/10/14	82/12/14	83/02/15
	INITIAL TIME-DEPTH-BOTTOM			1500 0001	1315 0001	1300 0001	1300 0001	1405 0001	1500	1155	1030
00010	WATER	TEMP	CENT	8.0	15.5	28.0 O	31.0	16.9		4.2	
00011	WATER	TEMP	FAHN	46.4	59.9	82.4	87.8	62.4		39.6	
00020	AIR	TEMP	CENT		18.0	35.0	32.0	25.0		13.0	30
00061	STREAM	FLOW,	INST-CFS					500		290	
00094	CNDUCTVY	FIELD	MICROMHO	420	300	450		510		294	
00095	CNDUCTVY	AT 25C	MICROMHO	418	305	467	452				
00116	INTNSVE	SURVEY	IDENT	820402	820401	820401	820401	820401	820401		
00300	DO		MG/L		9.5	13.0	10.6	13.2		12.8	
00301	DO	SATUR	PERCENT		95.0	164.6	141.3	136.1		97.7	
00400	PH		SU	8.30	8.20	8.70	8.90	8.49		9.96	
00403	LAB	PH	SU	8.5	8.5	8.8	8.7	8.5		7.9	
00410	T ALK	CACO3	MG/L	190	123	174	168	174		98	
00415	PHEN-PH-	LFIN ALK	MG/L	6	0	11	9	5		0	
00500	RESIDUE	TOTAL	MG/L	275	181	276	316	280		168	
00530	RESIDUE	TOT NFLT	MG/L	7	1 K	1 K	1 K	2		4	
00615	NO2-N	TOTAL	MG/L			0.010 K					
00625	TOT KJEL	N	MG/L	0.200 K	0.200 K	0.420	0.800	0.420		0.600	
00665	PHOS-TOT		MG/L P	0.030 K	0.030 K	0.050 K	0.620	0.050 K		0.050 K	
00671	PHOS-DIS	ORTHO	MG/L P		0.030 K	0.020	0.250	0.010 K		0.020	
00900	TOT HARD	CACO3	MG/L	152	110	152	139	164		98	
00916	CALCIUM	CA-TOT	MG/L	50.0	31.0	42.0	24.5	34.0		26.0	
00927	MGNSIUM	MG,TOT	MG/L	6.0	8.0	11.0	18.8	19.0		8.0	
00929	SODIUM	NA,TOT	MG/L	34.00	18.00	37.00	44.00	41.60		19.00	
00937	PTSSIUM	K,TOT	MG/L	4.00	4.00	6.00	8.10	6.90		3.30	
00940	CHLORIDE	TOTAL	MG/L	16	7	19	23	25		7	
00945	SULFATE	SO4-TOT	MG/L	10	9	8	10	10		12	
00951	FLUORIDE	F,TOTAL	MG/L	0.38	0.24	0.40	0.44	0.36		0.29	
01000	ARSENIC	AS,DISS	UG/L		20 K	20 K	20 K	20 K	20 K	20 K	20 K
01002	ARSENIC	AS,TOT	UG/L	20 K	20 K	20 K	20 K	20 K	20 K	20 K	5 K
01025	CADMIUM	CD,DISS	UG/L		5 K	5 K	5 K	5 K	5 K	5 K	5 K
01027	CADMIUM	CD,TOT	UG/L	5 K	5 K	5 K	5 K	5 K	5 K	5 K	10 K
01030	CHROMIUM	CR,DISS	UG/L		50 K	10 K	10 K	10 K	10 K	10 K	10 K
01034	CHROMIUM	CR,TOT	UG/L	50 K	50 K	10 K	10 K	10 K	10 K	10 K	10 K
01040	COPPER	CU,DISS	UG/L		50	50 K	10 K	10 K	10 K	10 K	10 K
01042	COPPER	CU,TOT	UG/L	50 K	50 K	50 K	28 K	10 K	10 K	10 K	10 K
01045	IRON	FE,TOT	UG/L	50 K	50 K	100 K	100 K	100 K	100 K	460	
01046	IRON	FE,DISS	UG/L		50 K	100 K	100 K	100 K	100 K	100 K	100 K
01049	LEAD	PB,DISS	UG/L		20 K	20 K	20 K	20 K	20 K	20 K	20 K
01051	LEAD	PB,TOT	UG/L	20 K	20 K	20 K	20 K	20 K	20 K	20 K	20 K
01055	MANGNESE	MN	UG/L	50.0 K	50.0 K	50.0 K	50.0 K	50.0 K	50.0 K	50.0 K	50.0 K
01056	MANGNESE	MN,DISS	UG/L		50.0 K	50.0 K	50.0 K	50.0 K	50.0 K	50.0 K	50.0 K
01060	MOLY	MO,DISS	UG/L		10 K	10 K	14		10 K	13	
01062	MOLY	MO,TOT	UG/L	10 K	10 K	42		10 K	10 K	10 K	10 K
01075	SILVER	AG,DISS	UG/L		50.0 K	5.0 K	5.0 K	5.0 K	5.0 K	5.0 K	5.0 K
01077	SILVER	AG,TOT	UG/L	50.0 K	50.0 K	5.0 K	5.0 K	5.0 K	5.0 K	5.0 K	5.0 K

(SAMPLE CONTINUED ON NEXT PAGE)

10671000006236 BC017 T16NR9WS7DB
34 44 30.0 113 14 30.0 2
BURRO CREEK ABOVE FRANCIS CREEK
04025 ARIZONA YAVAPAI
COLORADO RIVER 110100
LOWER COLORADO RIVER
21ARIZ
820227 DEPTH 1
/TYPA/AMBNT/STREAM

(SAMPLE CONTINUED FROM PREVIOUS PAGE)

INITIAL DATE				82/02/09	82/04/05	82/06/16	82/08/17	82/10/14	82/10/14	82/12/14	83/02/15
INITIAL TIME-DEPTH-BOTTOM				1500 0001	1315 0001	1300 0001	1300 0001	1405 0001	1500	1155	1030
01090	ZINC	ZN,DISS	UG/L		50 K	50 K	50 K	50 K		50 K	
01092	ZINC	ZN,TOT	UG/L	50 K	50 K	50 K	50 K	50 K		50 K	
01095	ANTIMONY	SB,DISS	UG/L		10 K	10 K	10 K	10 K		10 K	
01097	ANTIMONY	SB,TOT	UG/L	10 K	10 K	10 K	10 K	10 K		10 K	
01145	SELENIUM	SE,DISS	UG/L		5 K	5 K	5 K	5 K		5 K	
01147	SELENIUM	SE,TOT	UG/L	5 K	5 K	5 K	5 K	5 K		5 K	
31613	FEC COLI	M-FCAGAR	/100ML							5	
31625	FEC COLI	M-FCAGAD	/100 ML		6	12		2			
71850	NITRATE	TOT-NO3	MG/L	0.1 K	0.1	0.0	0.2 K	0.1		0.4 K	
71890	MERCURY	HG,DISS	UG/L		0.5 K	0.5 K	0.5 K	0.5 K		0.5 K	
71900	MERCURY	HG,TOTAL	UG/L	2.0 K	0.5 K	0.5 K	0.5 K	0.5 K		0.5 K	
82079	TURBIDTY	LAB	NTU	1.0	2.0	2.0	2.0	0.5		9.0	
82233	SILICON	SI TOTAL	MG/L		15.50	18.30	24.90	19.60		17.80	

INITIAL DATE				83/02/15	
INITIAL TIME-DEPTH-BOTTOM				1040	
00010	WATER	TEMP	CENT	4.8	
00011	WATER	TEMP	FAHN	40.6	
00020	AIR	TEMP	CENT	18.0	
00094	CNDUCTVY	FIELD	MICROMHO	163	
00095	CNDUCTVY	AT 25C	MICROMHO	197	
00300	DO		MG/L	11.2	
00301	DO	SATUR	PERCENT	87.5	
00400	PH		SU	8.30	
00403	LAB	PH	SU	7.7	
00410	T ALK	CACO3	MG/L	62	
00415	PHEN-PH-	LFIN ALK	MG/L	0	
00500	RESIDUE	TOTAL	MG/L	185	
00530	RESIDUE	TOT NFLT	MG/L	1	
00625	TOT KJEL	N	MG/L	2.100	
00665	PHOS-TOT		MG/L P	0.070	
00671	PHOS-DIS	ORTHO	MG/L P	0.070	
00900	TOT HARD	CACO3	MG/L	74	
00916	CALCIUM	CA-TOT	MG/L	19.0	
00927	MGNSIUM	MG,TOT	MG/L	6.0	
00929	SODIUM	NA,TOT	MG/L	10.00	
00937	PTSSIUM	K,TOT	MG/L	3.50	
00940	CHLORIDE	TOTAL	MG/L	3	
00945	SULFATE	SO4-TOT	MG/L	14	
00951	FLUORIDE	F,TOTAL	MG/L	0.19	
01000	ARSENIC	AS,DISS	UG/L	20 K	
01002	ARSENIC	AS,TOT	UG/L	20 K	
01025	CADMIUM	CD,DISS	UG/L	5 K	
01027	CADMIUM	CD,TOT	UG/L	5 K	
01030	CHROMIUM	CR,DISS	UG/L	10 K	

(SAMPLE CONTINUED ON NEXT PAGE)

STORET RETRIEVAL DATE 83/09/09
10671000006236 BC017 T16NR9WS7DB
34 44 30.0 113 14 30.0 2
BURRO CREEK ABOVE FRANCIS CREEK
04025 ARIZONA YAVAPAI
COLORADO RIVER 110100
LOWER COLORADO RIVER
21ARIZ
820227 DEPTH 1
/TYPA/AMBNT/STREAM

(SAMPLE CONTINUED FROM PREVIOUS PAGE)

	INITIAL DATE			83/02/15
	INITIAL TIME-DEPTH-BOTTOM			1040
01034	CHROMIUM	CR,TOT	UG/L	10 K
01040	COPPER	CU,DISS	UG/L	10 K
01042	COPPER	CU,TOT	UG/L	10 K
01045	IRON	FE,TOT	UG/L	3400
01046	IRON	FE,DISS	UG/L	1740
01049	LEAD	PB,DISS	UG/L	20 K
01051	LEAD	PB,TOT	UG/L	20 K
01055	MANGNESE	MN	UG/L	50.0 K
01056	MANGNESE	MN,DISS	UG/L	50.0 K
01060	MOLY	MO,DISS	UG/L	10 K
01062	MOLY	MO,TOT	UG/L	10 K
01075	SILVER	AG,DISS	UG/L	5.0 K
01077	SILVER	AG,TOT	UG/L	5.0 K
01090	ZINC	ZN,DISS	UG/L	50 K
01092	ZINC	ZN,TOT	UG/L	50 K
01095	ANTIMONY	SB,DISS	UG/L	10 K
01097	ANTIMONY	SB,TOT	UG/L	10 K
01145	SELENIUM	SE,DISS	UG/L	5 K
01147	SELENIUM	SE,TOT	UG/L	5 K
31613	FEC COLI	M-FCAGAR	/100ML	3 K
71850	NITRATE	TOT-NO3	MG/L	0.4 K
71890	MERCURY	HG,DISS	UG/L	0.5 K
71900	MERCURY	HG,TOTAL	UG/L	0.5 K
82079	TURBIDTY	LAB	NTU	33.0
82233	SILICON	SI TOTAL	MG/L	24.00

10671200000010 BC020 T15NR10WS28A
34 37 02.0 113 18 27.0 2
BOULDER CR AT MOUTH
04025 ARIZONA YAVAPAI
COLORADO RIVER 110100
LOWER COLORADO RIVER
21ARIZ
820227 DEPTH 1
/TYPA/AMBNT/STREAM

	INITIAL DATE			82/02/11	
	INITIAL TIME-DEPTH-BOTTOM			1130 0001	
00010	WATER	TEMP	CENT	8.5	
00011	WATER	TEMP	FAHN	47.3	
00094	CNDUCTVY	FIELD	MICROMHO	97	
00095	CNDUCTVY	AT 25C	MICROMHO	124	
00116	INTNSVE	SURVEY	IDENT	820401	
00300	DO		MG/L	10.6	
00301	DO	SATUR	PERCENT	91.4	
00400	PH		SU	7.20	
00403	LAB	PH	SU	7.2	
00410	T ALK	CACO3	MG/L	38	
00415	PHEN-PH-	LFIN ALK	MG/L	0	
00500	RESIDUE	TOTAL	MG/L	420	
00530	RESIDUE	TOT NFLT	MG/L	740	
00665	PHOS-TOT		MG/L P	0.070	
00900	TOT HARD	CACO3	MG/L	56	
00916	CALCIUM	CA-TOT	MG/L	18.0	
00927	MGNSIUM	MG,TOT	MG/L	3.0	
00929	SODIUM	NA,TOT	MG/L	4.00	
00937	PTSSIUM	K,TOT	MG/L	2.00	
00940	CHLORIDE	TOTAL	MG/L	2	
00945	SULFATE	SO4-TOT	MG/L	32	
00951	FLUORIDE	F,TOTAL	MG/L	0.43	
01000	ARSENIC	AS,DISS	UG/L	20	K
01002	ARSENIC	AS,TOT	UG/L	20	K
01025	CADMIUM	CD,DISS	UG/L	5	K
01027	CADMIUM	CD,TOT	UG/L	5	K
01030	CHROMIUM	CR,DISS	UG/L	50	K
01034	CHROMIUM	CR,TOT	UG/L	60	
01040	COPPER	CU,DISS	UG/L	50	K
01042	COPPER	CU,TOT	UG/L	140	
01045	IRON	FE,TOT	UG/L	2120	
01046	IRON	FE,DISS	UG/L	240	
01049	LEAD	PB,DISS	UG/L	20	K
01051	LEAD	PB,TOT	UG/L	20	K
01055	MANGNESE	MN	UG/L	830.0	
01056	MANGNESE	MN,DISS	UG/L	50.0	K
01060	MOLY	MO,DISS	UG/L	20	K
01062	MOLY	MO,TOT	UG/L	10	K
01075	SILVER	AG,DISS	UG/L	50.0	K
01077	SILVER	AG,TOT	UG/L	50.0	K
01090	ZINC	ZN,DISS	UG/L	50	K
01092	ZINC	ZN,TOT	UG/L	160	
01095	ANTIMONY	SB,DISS	UG/L	10	K
01097	ANTIMONY	SB,TOT	UG/L	10	K
01145	SELENIUM	SE,DISS	UG/L	5	K

(SAMPLE CONTINUED ON NEXT PAGE)

STORET RETRIEVAL DATE 83/09/09
106712000000010 BC020 T15NR10WS28A
34 37 02.0 113 18 27.0 2
BOULDER CR AT MOUTH
04025 ARIZONA YAVAPAI
COLORADO RIVER 110100
LOWER COLORADO RIVER
21ARIZ
820227 DEPTH 1
/TYPA/AMBNT/STREAM

(SAMPLE CONTINUED FROM PREVIOUS PAGE)

	INITIAL DATE			82/02/11
	INITIAL TIME-DEPTH-BOTTOM			1130 0001
01147	SELENIUM	SE,TOT	UG/L	5 K
71850	NITRATE	TOT-NO3	MG/L	1.9
71890	MERCURY	HG,DISS	UG/L	2.0 K
71900	MERCURY	HG,TOTAL	UG/L	2.0 K
82079	TURBIDTY	LAB	NTU	380.0

STORET RETRIEVAL DATE 83/09/09
10671200000101 BC021
34 36 45.0 113 17 56.0 2
BOULDER CR AT RD TO OLD PUMPHOUSE
04025 ARIZONA YAVAPAI
COLORADO RIVER 110100
LOWER COLORADO RIVER
21ARIZ
830205 DEPTH 1
/TYPA/AMBNT/STREAM

	INITIAL DATE			82/04/07	82/06/18	82/12/11	83/02/17
	INITIAL TIME-DEPTH-BOTTOM			1220 0001	1000 0001	1300	1200
00010	WATER	TEMP	CENT	18.9	24.8	8.5	10.0
00011	WATER	TEMP	FAHN	66.0	76.6	47.3	50.0
00020	AIR	TEMP	CENT	20.0	34.0	22.0	18.3
00061	STREAM	FLOW,	INST-CFS	4		186	12
00094	CNDUCTVY	FIELD	MICROMHO	500	875	117	370
00095	CNDUCTVY	AT 25C	MICROMHO	556	926	131	332
00116	INTNSVE	SURVEY	.IDENT	820401	820401		
00300	DO		MG/L	9.2	6.2	11.7	11.4
00301	DO	SATUR	PERCENT	97.9	73.8	100.9	100.9
00400	PH		SU	8.10	7.50	7.25	8.50
00403	LAB	PH	SU	8.2	7.5	7.5	7.9
00410	T ALK	CACO3	MG/L	98	158	28	64
00415	PHEN-PH-	LFIN ALK	MG/L	0	0	0	0
00500	RESIDUE	TOTAL	MG/L	311	660	111	24
00530	RESIDUE	TOT NFLT	MG/L	1 K	5	36	
00625	TOT KJEL	N	MG/L	0.560	0.360	1.100	0.900
00665	PHOS-TOT		MG/L P	0.050	0.050 K	0.050 K	0.050 K
00671	PHOS-DIS	ORTHO	MG/L P	0.010 K	0.010 K	0.080	0.020
00900	TOT HARD	CACO3	MG/L	1 K	376	44	122
00916	CALCIUM	CA-TOT	MG/L	55.0	94.0	13.0	34.8
00927	MGNSIUM	MG,TOT	MG/L	12.0	34.0	3.0	8.0
00929	SODIUM	NA,TOT	MG/L	31.00	67.00	10.00 K	19.70
00937	PTSSIUM	K,TOT	MG/L	4.20	7.00	2.60	2.80
00940	CHLORIDE	TOTAL	MG/L	15	41	1	8
00945	SULFATE	SO4-TOT	MG/L	106	248	21	57
00951	FLUORIDE	F,TOTAL	MG/L	2.68	2.72	0.54	1.65
01000	ARSENIC	AS,DISS	UG/L	20 K	20	20 K	20 K
01002	ARSENIC	AS,TOT	UG/L	20 K	30	20 K	20 K
01025	CADMIUM	CD,DISS	UG/L	5 K	5 K	5 K	5 K
01027	CADMIUM	CD,TOT	UG/L	5 K	5 K	5 K	5 K
01030	CHROMIUM	CR,DISS	UG/L	50 K	10	10 K	10 K
01034	CHROMIUM	CR,TOT	UG/L	50 K	10 K	10 K	10 K
01040	COPPER	CU,DISS	UG/L	50 K		10 K	20
01042	COPPER	CU,TOT	UG/L	50 K	50 K	12	20
01045	IRON	FE,TOT	UG/L	50 K	100 K	4650	450
01046	IRON	FE,DISS	UG/L	50 K		160	160
01049	LEAD	PB,DISS	UG/L	20 K	20 K	20 K	20 K
01051	LEAD	PB,TOT	UG/L	20 K	20 K	20 K	20 K
01055	MANGNESE	MN	UG/L	50.0 K	100.0	80.0	50.0 K
01056	MANGNESE	MN,DISS	UG/L	50.0 K		50.0 K	50.0 K
01060	MOLY	MO,DISS	UG/L	43	45	10 K	40
01062	MOLY	MO,TOT	UG/L	10 K	47	10 K	30
01075	SILVER	AG,DISS	UG/L	50.0 K	5.0 K	5.0 K	5.0 K
01077	SILVER	AG,TOT	UG/L	50.0 K	5.0 K	5.0 K	5.0 K
01090	ZINC	ZN,DISS	UG/L	50 K		120	240

(SAMPLE CONTINUED ON NEXT PAGE)

STORET RETRIEVAL DATE 83/09/09
10671200000101 BC021
34 36 45.0 113 17 56.0 2
BOULDER CR AT RD TO OLD PUMPHOUSE
04025 ARIZONA YAVAPAI
COLORADO RIVER 110100
LOWER COLORADO RIVER
21ARIZ
830205 DEPTH 1
/TYPA/AMBNT/STREAM

(SAMPLE CONTINUED FROM PREVIOUS PAGE)

INITIAL DATE				82/04/07	82/06/18	82/12/11	83/02/17
INITIAL TIME-DEPTH-BOTTOM				1220 0001	1000 0001	1300	1200
01092	ZINC	ZN,TOT	UG/L	50 K	50 K	50 K	50 K
01095	ANTIMONY	SB,DISS	UG/L	10 K	10 K	10 K	10 K
01097	ANTIMONY	SB,TOT	UG/L	17	10	10 K	10 K
01145	SELENIUM	SE,DISS	UG/L	5 K	5 K	5 K	5 K
01147	SELENIUM	SE,TOT	UG/L	5 K	5 K	5 K	5 K
01501	ALPHA	TOTAL	PC/L				3
01502	ALPHA-T	ERROR	PC/L				1
03501	BETA	TOTAL	PC/L				3 K
22708	U-NAT	TOTAL	MG/L				0.011
31613	FEC COLI	M-FCAGAR	/100ML			160	3 K
31625	FEC COLI	M-FCAGAD	/100 ML	6	2		
71850	NITRATE	TOT-NO3	MG/L	0.1	0.2	0.4	0.4 K
71890	MERCURY	HG,DISS	UG/L	0.5 K	0.5 K	0.5 K	0.5 K
71900	MERCURY	HG,TOTAL	UG/L	0.5 K	0.5 K	0.5 K	0.5 K
82079	TURBIDTY	LAB	NTU	2.0	2.0	44.0	9.6
82233	SILICON	SI TOTAL	MG/L	8.80	7.30	24.90	9.90

STORET RETRIEVAL DATE 83/09/09
10671200000320 BC023 T15NR10WS25A
34 36 43.0 113 15 34.0 2
BOULDER CR BELOW OLD C-B TAILINGS
04025 ARIZONA YAVAPAI
COLORADO RIVER 110100
LOWER COLORADO RIVER
21ARIZ
820227 DEPTH 1
/TYPA/AMBNT/STREAM

	INITIAL DATE			82/02/11		82/04/07		82/12/11		83/02/17	
	INITIAL TIME-DEPTH-BOTTOM			0945 0001		1030 0001		1000		1000	
00010	WATER	TEMP	CENT	7.5		15.0		6.0		5.8	
00011	WATER	TEMP	FAHN	45.5		59.0		42.8		42.4	
00020	AIR	TEMP	CENT			19.0		20.0		19.0	
00094	CNDUCTVY	FIELD	MICROMHO	82		390		95		225	
00095	CNDUCTVY	AT 25C	MICROMHO	104		394		115		238	
00116	INTNSVE	SURVEY	IDENT	820401		820401					
00300	DO		MG/L	11.4		10.6		12.3		11.7	
00301	DO	SATUR	PERCENT	95.8		103.9		98.4		93.6	
00400	PH		SU	7.30		8.60		7.04		8.85	
00403	LAB	PH	SU	7.2		8.5		7.2		8.0	
00410	T ALK	CACO3	MG/L	32		75		28		47	
00415	PHEN-PH-	LPIN ALK	MG/L	0		0		0		0	
00500	RESIDUE	TOTAL	MG/L	570		244		98		176	
00530	RESIDUE	TOT NFLT	MG/L	1130		6		33		1	K
00625	TOT KJEL	N	MG/L	0.200	K	0.600		1.200		0.900	
00665	PHOS-TOT		MG/L P	0.160		0.050	K	0.050	K	0.050	K
00671	PHOS-DIS	ORTHO	MG/L P			0.010	K	0.120		0.010	
00900	TOT HARD	CACO3	MG/L	52		130		40		86	
00916	CALCIUM	CA-TOT	MG/L	16.0		34.0		12.0		23.0	
00927	MGNSIUM	MG,TOT	MG/L	3.0		11.0		2.0		7.0	
00929	SODIUM	NA,TOT	MG/L	3.00		22.00		10.00	K	13.40	
00937	PTSSIUM	K,TOT	MG/L	2.00		2.90		2.50		2.00	
00940	CHLORIDE	TOTAL	MG/L	2		10		2		5	
00945	SULFATE	SO4-TOT	MG/L	31		72		20		37	
00951	FLUORIDE	F,TOTAL	MG/L	0.36		1.66		0.54		1.15	
01000	ARSENIC	AS,DISS	UG/L	20	K	20	K	20	K	20	K
01002	ARSENIC	AS,TOT	UG/L	20	K	20	K	20	K	20	K
01025	CADMIUM	CD,DISS	UG/L	5	K	5	K	5	K	5	K
01027	CADMIUM	CD,TOT	UG/L	5	K	5	K	5	K	5	K
01030	CHROMIUM	CR,DISS	UG/L	50	K	50	K	10	K	10	K
01034	CHROMIUM	CR,TOT	UG/L	70		50	K	10	K	10	K
01040	COPPER	CU,DISS	UG/L	50	K	50	K	10	K	20	
01042	COPPER	CU,TOT	UG/L	180		50	K	10	K	10	
01045	IRON	FE,TOT	UG/L	2250		50	K	4550		900	
01046	IRON	FE,DISS	UG/L	130		50	K	160		290	
01049	LEAD	PB,DISS	UG/L	20	K	20	K	20	K	20	K
01051	LEAD	PB,TOT	UG/L	20	K	20	K	20	K	20	K
01055	MANGNESE	MN	UG/L	1000.0		50.0	K	70.0		50.0	K
01056	MANGNESE	MN,DISS	UG/L	50.0	K	50.0	K	50.0	K	50.0	K
01060	MOLY	MO,DISS	UG/L	10	K	0		15		10	K
01062	MOLY	MO,TOT	UG/L	10	K	11		260		10	
01075	SILVER	AG,DISS	UG/L	50.0	K	50.0	K	5.0	K	5.0	K
01077	SILVER	AG,TOT	UG/L	50.0	K	50.0	K	5.0	K	5.0	K
01090	ZINC	ZN,DISS	UG/L	50	K	50	K	50	K	50	K
01092	ZINC	ZN,TOT	UG/L	200		50	K	50	K	50	K

(SAMPLE CONTINUED ON NEXT PAGE)

10671200000320 BC023 T15NR10WS25A
34 36 43.0 113 15 34.0 2
BOULDER CR BELOW OLD C-B TAILINGS
04025 ARIZONA YAVAPAI
COLORADO RIVER 110100
LOWER COLORADO RIVER
21ARIZ
820227 DEPTH 1
/TYPA/AMBNT/STREAM

(SAMPLE CONTINUED FROM PREVIOUS PAGE)

	INITIAL DATE			82/02/11	82/04/07	82/12/11	83/02/17	
	INITIAL TIME-DEPTH-BOTTOM			0945 0001	1030 0001	1000	1000	
01095	ANTIMONY	SB,DISS	UG/L	10 K	10 K	10 K	10 K	
01097	ANTIMONY	SB,TOT	UG/L	10 K	10 K	10 K	10 K	
01145	SELENIUM	SE,DISS	UG/L	5 K	5 K	5 K	5 K	
01147	SELENIUM	SE,TOT	UG/L	5 K	5 K	5 K	5 K	
01501	ALPHA	TOTAL	PC/L				2	
01502	ALPHA-T	ERROR	PC/L				1	
03501	BETA	TOTAL	PC/L				3	K
22708	U-NAT	TOTAL	MG/L				0.007	
31625	FEC COLI	M-PCAGAD	/100 ML		44			
71850	NITRATE	TOT-NO3	MG/L	1.9	0.1	0.4 K	0.4 K	
71890	MERCURY	HG,DISS	UG/L	2.0 K	0.5 K	0.5 K	0.5 K	
71900	MERCURY	HG,TOTAL	UG/L	2.0 K	0.5 K	0.5 K	0.5 K	
82079	TURBIDTY	LAB	NTU	400.0	4.0	44.0	10.0	
82233	SILICON	SI TOTAL	MG/L		7.60	22.40	9.30	

106712000000473 BC024 T15NR9WS30DD
34 36 30.0 113 13 54.0 2
BOULDER CR BELOW COPPER CR
04025 ARIZONA YAVAPAI
COLORADO RIVER 110100
LOWER COLORADO RIVER
21ARIZ
820227 DEPTH 1
/TYPA/AMBNT/STREAM

INITIAL DATE				82/02/10	82/04/07	82/06/18	82/08/19	82/08/19	82/10/16	82/10/16	82/12/11
INITIAL TIME-DEPTH-BOTTOM				0945 0001	0900 0001	0800 0001	1015	1030 0001	1300 0001	1400	0900
00010	WATER	TEMP	CENT	8.0	12.0	20.5		27.0	20.0		6.0
00011	WATER	TEMP	FAHN	46.4	53.6	68.9		80.6	68.0		42.8
00020	AIR	TEMP	CENT		19.0	32.0		33.0	25.0		15.0
00061	STREAM	FLOW,	INST-CFS		6	0	0			0	
00094	CNDUCTVY	FIELD	MICROMHO	620	390			3500	3000		175
00095	CNDUCTVY	AT 25C	MICROMHO	649	385	1923		2273	2439		118
00116	INTNSVE	SURVEY	IDENT	820401	820401	820401		820401	820401		
00300	DO		MG/L	12.3		7.3		6.8	10.4		13.6
00301	DO	SATUR	PERCENT	103.4		81.1		84.0	113.0		108.8
00400	PH		SU	8.22	8.60	7.50		7.30	7.35		7.49
00403	LAB	PH	SU	8.1	8.2	7.4		7.7	7.3		7.2
00410	T ALK	CACO3	MG/L	136	77	138		163	128		27
00415	PHEN-PH-	LFIN ALK	MG/L	0	0	0		0	0 U		0
00500	RESIDUE	TOTAL	MG/L	402	240	1805		2022	2408		96
00530	RESIDUE	TOT NFLT	MG/L	11	3	1 K		2	7		49
00615	NO2-N	TOTAL	MG/L	0.200 K							
00625	TOT KJEL	N	MG/L	0.200 K	0.200 K	0.130		0.100 K	1.300		1.200
00665	PHOS-TOT		MG/L P	0.050	0.050 K	0.050 K		0.220	0.050 K		0.050 K
00671	PHOS-DIS	ORTHO	MG/L P		0.010 K	0.010 K			0.010 K		0.050
00900	TOT HARD	CACO3	MG/L	224	130	1110		1253	1410		38
00916	CALCIUM	CA-TOT	MG/L	60.0	35.0	264.0		273.5	336.0		11.0
00927	MGNSIUM	MG,TOT	MG/L	18.0	10.0	108.0		138.5	137.0		2.0
00929	SODIUM	NA,TOT	MG/L	41.00	20.00	115.00		155.00	147.40		10.00 K
00937	PTSSIUM	K,TOT	MG/L	3.00	2.80	12.00		14.80	13.80		2.40
00940	CHLORIDE	TOTAL	MG/L	17	10	58		83	82		1
00945	SULFATE	SO4-TOT	MG/L	133	70	994		1098	1408		19
00951	FLUORIDE	F,TOTAL	MG/L	1.97	1.48	2.29		3.11	2.81		0.43
01000	ARSENIC	AS,DISS	UG/L	25	20 K	21		30	20		20 K
01002	ARSENIC	AS,TOT	UG/L	27	20 K	20 K		40	20 K		20 K
01025	CADMIUM	CD,DISS	UG/L	5 K	5 K	5 K		5 K	5 K		5 K
01027	CADMIUM	CD,TOT	UG/L	5 K	5 K	5 K		5 K	5 K		5 K
01030	CHROMIUM	CR,DISS	UG/L	50 K	50 K	10 K		10 K	10 K		10 K
01034	CHROMIUM	CR,TOT	UG/L	50 K	50 K	10 K		10 K	10 K		10 K
01040	COPPER	CU,DISS	UG/L	50 K	50 K			10	0		11
01042	COPPER	CU,TOT	UG/L	50 K	50 K	50 K		13	30		10 K
01045	IRON	FE,TOT	UG/L	380	50 K	100 K		100 K	110		4550
01046	IRON	FE,DISS	UG/L	50 K	50 K			100 K	100 K		160
01049	LEAD	PB,DISS	UG/L	20 K	20 K	20 K		20 K	20 K		20 K
01051	LEAD	PB,TOT	UG/L	20 K	2 K	20 K		20 K	20 K		20 K
01055	MANGNESE	MN	UG/L	90.0	50.0 K	350.0		230.0	240.0		80.0
01056	MANGNESE	MN,DISS	UG/L	80.0	50.0 K			210.0	0.2		50.0 K
01060	MOLY	MO,DISS	UG/L	20	17	29		0	14		
01062	MOLY	MO,TOT	UG/L	10 K	10 K	25		15	10 K		15
01075	SILVER	AG,DISS	UG/L	50.0 K	50.0 K	5.0 K		5.0 K	5.0 K		5.0 K
01077	SILVER	AG,TOT	UG/L	50.0 K	50.0 K	5.0 K		5.0 K	5.0 K		5.0 K

(SAMPLE CONTINUED ON NEXT PAGE)

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 10671200000473 BC024        T15NR9WS30DD
34 36 30.0 113 13 54.0  2
BOULDER CR BELOW COPPER CR
04025 ARIZONA             YAVAPAI
COLORADO RIVER             110100
LOWER COLORADO RIVER
21ARIZ
        820227     DEPTH     1
/TYPA/AMBNT/STREAM
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(SAMPLE CONTINUED FROM PREVIOUS PAGE)

	INITIAL DATE			82/02/10	82/04/07	82/06/18	82/08/19	82/08/19	82/10/16	82/10/16	82/12/11
	INITIAL TIME-DEPTH-BOTTOM			0945 0001	0900 0001	0800 0001	1015	1030 0001	1300 0001	1400	0900
01090	ZINC	ZN,DISS	UG/L	50 K	50 K			90	0		50 K
01092	ZINC	ZN,TOT	UG/L	80	50 K	60		50 K	50 K		50 K
01095	ANTIMONY	SB,DISS	UG/L	10	10 K	10 K		10	10 K		
01097	ANTIMONY	SB,TOT	UG/L	10	10 K	10 K		14	10 K		10 K
01145	SELENIUM	SE,DISS	UG/L	5 K	5 K	5 K		5 K	5 K		5 K
01147	SELENIUM	SE,TOT	UG/L	5 K	5 K	5 K		5 K	5 K		5 K
31613	FEC COLI	M-FCAGAR	/100ML								130
31625	FEC COLI	M-FCAGAD	/100 ML	40	2 K	2 K		68	30		
71850	NITRATE	TOT-NO3	MG/L	0.7	0.4	0.5		0.2 K	0.4 K		0.4 K
71890	MERCURY	HG,DISS	UG/L	2.0 K	0.5 K	0.5 K		0.5 K	0.5 K		0.5 K
71900	MERCURY	HG,TOTAL	UG/L	2.0 K	0.5 K	0.5 K		0.5 K	0.5 K		0.5 K
82079	TURBIDTY	LAB	NTU	9.0	4.0	2.0		2.0	2.0		46.0
82233	SILICON	SI TOTAL	MG/L	12.64	9.60	5.80		15.50	12.90		22.40
	INITIAL DATE			83/02/17							
	INITIAL TIME-DEPTH-BOTTOM			0915							
00010	WATER	TEMP	CENT	9.0							
00011	WATER	TEMP	FAHN	48.2							
00020	AIR	TEMP	CENT	14.0							
00061	STREAM	FLOW,	INST-CFS	8							
00094	CNDUCTVY	FIELD	MICROMHO	186							
00095	CNDUCTVY	AT 25C	MICROMHO	229							
00300	DO		MG/L	11.8							
00301	DO	SATUR	PERCENT	101.7							
00400	PH		SU	8.80							
00403	LAB	PH	SU	7.5							
00410	T ALK	CACO3	MG/L	47							
00415	PHEN-PH-	LPIN ALK	MG/L	0							
00500	RESIDUE	TOTAL	MG/L	172							
00530	RESIDUE	TOT NFLT	MG/L	1 K							
00625	TOT KJEL	N	MG/L	1.000							
00665	PHOS-TOT		MG/L P	0.050 K							
00671	PHOS-DIS	ORTHO	MG/L P	0.030							
00900	TOT HARD	CACO3	MG/L	82							
00916	CALCIUM	CA-TOT	MG/L	22.0							
00927	MGNSIUM	MG,TOT	MG/L	6.0							
00929	SODIUM	NA,TOT	MG/L	12.20							
00937	PTSSIUM	K,TOT	MG/L	2.00							
00940	CHLORIDE	TOTAL	MG/L	5							
00945	SULFATE	SO4-TOT	MG/L	32							
00951	FLUORIDE	F,TOTAL	MG/L	1.00							
01000	ARSENIC	AS,DISS	UG/L	20 K							
01002	ARSENIC	AS,TOT	UG/L	20 K							
01025	CADMIUM	CD,DISS	UG/L	5 K							
01027	CADMIUM	CD,TOT	UG/L	5 K							

(SAMPLE CONTINUED ON NEXT PAGE)

10671200000473 BC024 T15NR9WS30DD
34 36 30.0 113 13 54.0 2
BOULDER CR BELOW COPPER CR
04025 ARIZONA YAVAPAI
COLORADO RIVER 110100
LOWER COLORADO RIVER
21ARIZ
820227 DEPTH 1
/TYPA/AMBNT/STREAM

(SAMPLE CONTINUED FROM PREVIOUS PAGE)

	INITIAL DATE			83/02/17	
	INITIAL TIME-DEPTH-BOTTOM			0915	
01030	CHROMIUM	CR,DISS	UG/L	10	K
01034	CHROMIUM	CR,TOT	UG/L	10	K
01040	COPPER	CU,DISS	UG/L	10	
01042	COPPER	CU,TOT	UG/L	10	K
01045	IRON	FE,TOT	UG/L	900	
01046	IRON	FE,DISS	UG/L	420	
01049	LEAD	PB,DISS	UG/L	20	K
01051	LEAD	PB,TOT	UG/L	20	K
01055	MANGNESE	MN	UG/L	5.0	K
01056	MANGNESE	MN,DISS	UG/L	50.0	K
01060	MOLY	MO,DISS	UG/L	10	K
01062	MOLY	MO,TOT	UG/L	10	K
01075	SILVER	AG,DISS	UG/L	5.0	K
01077	SILVER	AG,TOT	UG/L	5.0	K
01090	ZINC	ZN,DISS	UG/L	50	K
01092	ZINC	ZN,TOT	UG/L	50	K
01095	ANTIMONY	SB,DISS	UG/L	10	K
01097	ANTIMONY	SB,TOT	UG/L	10	K
01145	SELENIUM	SE,DISS	UG/L	5	K
01147	SELENIUM	SE,TOT	UG/L	5	K
01501	ALPHA	TOTAL	PC/L	3	
01502	ALPHA-T	ERROR	PC/L	1	
03501	BETA	TOTAL	PC/L	4	
03502	BETA-T	ERROR	PC/L	2	
22708	U-NAT	TOTAL	MG/L	0.008	
31613	FEC COLI	M-FCAGAR	/100ML	3	K
71850	NITRATE	TOT-NO3	MG/L	0.7	
71890	MERCURY	HG,DISS	UG/L	0.5	K
71900	MERCURY	HG,TOTAL	UG/L	0.5	K
82079	TURBIDTY	LAB	NTU	9.0	
82233	SILICON	SI TOTAL	MG/L	9.90	

106712000000573 BC025 T15NR9W29CCB
34 36 32.0 113 13 50.0 2
BOULDER CR ABOVE COPPER CR
04025 ARIZONA YAVAPAI
COLORADO RIVER 110100
LOWER COLORADO RIVER
21ARIZ
820227 DEPTH 1
/TYPA/AMBNT/STREAM

	INITIAL DATE			82/02/10	
	INITIAL TIME-DEPTH-BOTTOM			0945 0001	
00010	WATER	TEMP	CENT	8.0	
00011	WATER	TEMP	FAHN	46.4	
00094	CNDUCTVY	FIELD	MICROMHO	605	
00095	CNDUCTVY	AT 25C	MICROMHO	645	
00116	INTNSVE	SURVEY	IDENT	820401	
00300	DO		MG/L	11.3	
00301	DO	SATUR	PERCENT	95.0	
00400	PH		SU	8.15	
00403	LAB	PH	SU	8.0	
00410	T ALK	CACO3	MG/L	136	
00415	PHEN-PH-	LFIN ALK	MG/L	0	
00500	RESIDUE	TOTAL	MG/L	415	
00530	RESIDUE	TOT NFLT	MG/L	15	
00625	TOT KJEL	N	MG/L	0.200	K
00665	PHOS-TOT		MG/L P	0.050	
00900	TOT HARD	CACO3	MG/L	222	
00916	CALCIUM	CA-TOT	MG/L	58.0	
00927	MGNSIUM	MG,TOT	MG/L	18.0	
00929	SODIUM	NA,TOT	MG/L	40.00	
00937	PTSSIUM	K,TOT	MG/L	3.00	
00940	CHLORIDE	TOTAL	MG/L	17	
00945	SULFATE	SO4-TOT	MG/L	132	
00951	FLUORIDE	F,TOTAL	MG/L	1.97	
01000	ARSENIC	AS,DISS	UG/L	20	K
01002	ARSENIC	AS,TOT	UG/L	26	
01025	CADMIUM	CD,DISS	UG/L	5	K
01027	CADMIUM	CD,TOT	UG/L	5	K
01030	CHROMIUM	CR,DISS	UG/L	50	K
01034	CHROMIUM	CR,TOT	UG/L	50	K
01040	COPPER	CU,DISS	UG/L	50	K
01042	COPPER	CU,TOT	UG/L	50	K
01045	IRON	FE,TOT	UG/L	380	
01046	IRON	FE,DISS	UG/L	50	K
01049	LEAD	PB,DISS	UG/L	20	K
01051	LEAD	PB,TOT	UG/L	20	K
01055	MANGNESE	MN	UG/L	110.0	
01056	MANGNESE	MN,DISS	UG/L	100.0	
01060	MOLY	MO,DISS	UG/L	10	K
01062	MOLY	MO,TOT	UG/L	10	
01075	SILVER	AG,DISS	UG/L	50.0	K
01077	SILVER	AG,TOT	UG/L	50.0	K
01090	ZINC	ZN,DISS	UG/L	60	
01092	ZINC	ZN,TOT	UG/L	90	
01095	ANTIMONY	SB,DISS	UG/L	10	K
01097	ANTIMONY	SB,TOT	UG/L	10	

(SAMPLE CONTINUED ON NEXT PAGE)

STORET RETRIEVAL DATE 83/09/09
106712000000573 BC025 T15NR9W29CCB
34 36 32.0 113 13 50.0 2
BOULDER CR ABOVE COPPER CR
04025 ARIZONA YAVAPAI
COLORADO RIVER 110100
LOWER COLORADO RIVER
21ARIZ
820227 DEPTH 1
/TYPA/AMBNT/STREAM

(SAMPLE CONTINUED FROM PREVIOUS PAGE)

	INITIAL DATE			82/02/10	
	INITIAL TIME-DEPTH-BOTTOM			0945 0001	
01145	SELENIUM	SE,DISS	UG/L	5	K
01147	SELENIUM	SE,TOT	UG/L	5	K
71850	NITRATE	TOT-NO3	MG/L	0.9	
71890	MERCURY	HG,DISS	UG/L	2.0	K
71900	MERCURY	HG,TOTAL	UG/L	2.0	K
82079	TURBIDTY	LAB	NTU	10.0	
82233	SILICON	SI TOTAL	MG/L	11.54	

STORET RETRIEVAL DATE 83/09/09
10671200000612 BC025.5
34 36 35.0 113 13 39.0 2
SIDE SPR, BOULDER CR BELOW FRANCIS CR RD X-ING
04025 ARIZONA YAVAPAI
COLORADO RIVER 110100
LOWER COLORADO RIVER
21ARIZ
830205 DEPTH 1
/TYPA/AMBNT/STREAM

	INITIAL DATE			82/10/17		82/12/12	83/02/16	
	INITIAL TIME-DEPTH-BOTTOM			0845 0001		1515	1700	
00010	WATER	TEMP	CENT	10.0		7.9	8.5	
00011	WATER	TEMP	FAHN	50.0		46.2	47.3	
00020	AIR	TEMP	CENT	20.0		20.0	21.0	
00094	CNDUCTVY	FIELD	MICROMHO	2900		2900	1350	
00095	CNDUCTVY	AT 25C	MICROMHO	2325		2325	1030	
00116	INTNSVE	SURVEY	IDENT	820401				
00300	DO		MG/L	10.8		12.2	12.4	
00301	DO	SATUR	PERCENT	95.6		102.5	106.9	
00400	PH		SU	7.85		8.20	8.14	
00403	LAB	PH	SU	8.0		7.9	7.8	
00410	T ALK	CACO3	MG/L	194		146	86	
00415	PHEN-PH-	LFIN ALK	MG/L	0	U	0	0	
00500	RESIDUE	TOTAL	MG/L	2348		2199	1047	
00530	RESIDUE	TOT NFLT	MG/L	6		4	14	
00625	TOT KJEL	N	MG/L	1.000		0.500	0.300	
00665	PHOS-TOT		MG/L P	0.140		0.050	0.050	K
00900	TOT HARD	CACO3	MG/L	1530		1420	664	
00916	CALCIUM	CA-TOT	MG/L	368.0		368.0	190.0	
00927	MGNSIUM	MG,TOT	MG/L	146.0		120.0	45.0	
00929	SODIUM	NA,TOT	MG/L	90.30		82.80	44.90	
00937	PTSSIUM	K,TOT	MG/L	7.40		6.50	5.60	
00940	CHLORIDE	TOTAL	MG/L	62		60	37	
00945	SULFATE	SO4-TOT	MG/L	1368		1324	552	
00951	FLUORIDE	F,TOTAL	MG/L	1.38		1.48	1.30	
01002	ARSENIC	AS,TOT	UG/L	20	K	20 K	20	K
01027	CADMIUM	CD,TOT	UG/L	5	K	5 K	5	K
01034	CHROMIUM	CR,TOT	UG/L	10	K	10 K	10	K
01042	COPPER	CU,TOT	UG/L	27		10 K	30	
01045	IRON	FE,TOT	UG/L	110		130	200	
01051	LEAD	PB,TOT	UG/L	20	K	20 K	20	K
01055	MANGNESE	MN	UG/L	110.0		180.0	80.0	
01062	MOLY	MO,TOT	UG/L	11		10 K	40	
01077	SILVER	AG,TOT	UG/L	5.0	K	5.0 K	5.0	K
01092	ZINC	ZN,TOT	UG/L	50	K	50 K	50	K
01097	ANTIMONY	SB,TOT	UG/L	10	K	10 K	10	K
01147	SELENIUM	SE,TOT	UG/L	5	K	5 K	5	K
71850	NITRATE	TOT-NO3	MG/L	10.2		12.4	15.3	
71900	MERCURY	HG,TOTAL	UG/L	0.5	K	0.5 K	0.5	K
82079	TURBIDTY	LAB	NTU	2.5		4.0	4.5	
82233	SILICON	SI TOTAL	MG/L	26.40		19.30	16.90	

106712000000613 BC026 . T15NR9WS29CA
34 36 36.0 113 13 38.0 2
BOULDER CR AT FRANCIS CR RD X-ING
04025 ARIZONA YAVAPAI
COLORADO RIVER 110100
LOWER COLORADO RIVER
21ARIZ
820227 DEPTH 1
/TYPA/AMBNT/STREAM

	INITIAL DATE			82/02/10	82/10/02
	INITIAL TIME-DEPTH-BOTTOM			1130 0001 1130	
00095	CNDUCTVY	AT 25C	MICROMHO	355	
00116	INTNSVE	SURVEY	IDENT	820401	820401
00403	LAB	PH	SU	8.2	
00410	T ALK	CACO3	MG/L	122	
00415	PHEN-PH-	LFIN ALK	MG/L	0	
00500	RESIDUE	TOTAL	MG/L	235	
00530	RESIDUE	TOT NFLT	MG/L	6	
00625	TOT KJEL	N	MG/L	0.200	K
00665	PHOS-TOT		MG/L P	0.060	
00900	TOT HARD	CACO3	MG/L	106	
00916	CALCIUM	CA-TOT	MG/L	33.0	
00927	MGNSIUM	MG,TOT	MG/L	48.0	
00929	SODIUM	NA,TOT	MG/L	29.00	
00937	PTSSIUM	K,TOT	MG/L	2.00	
00940	CHLORIDE	TOTAL	MG/L	10	
00945	SULFATE	SO4-TOT	MG/L	29	
00951	FLUORIDE	F,TOTAL	MG/L	1.90	
01002	ARSENIC	AS,TOT	UG/L	30	
01027	CADMIUM	CD,TOT	UG/L	5	K
01034	CHROMIUM	CR,TOT	UG/L	50	K
01042	COPPER	CU,TOT	UG/L	50	K
01045	IRON	FE,TOT	UG/L	480	
01051	LEAD	PB,TOT	UG/L	20	K
01055	MANGNESE	MN	UG/L	130.0	
01062	MOLY	MO,TOT	UG/L	10	K
01077	SILVER	AG,TOT	UG/L	50.0	K
01092	ZINC	ZN,TOT	UG/L	110	
01097	ANTIMONY	SB,TOT	UG/L	10	K
01147	SELENIUM	SE,TOT	UG/L	5	K
71850	NITRATE	TOT-NO3	MG/L	0.1	K
71900	MERCURY	HG,TOTAL	UG/L	2.0	K
82079	TURBIDTY	LAB	NTU	13.0	
82233	SILICON	SI TOTAL	MG/L	14.84	

106712000000798 BC027 T15NR9WS29AB
34 37 10.0 113 13 06.0 2
BOULDER CR BELOW BUTTE CR
04025 ARIZONA YAVAPAI
COLORADO RIVER 110100
LOWER COLORADO RIVER
21ARIZ
820227 DEPTH 1
/TYPA/AMBNT/STREAM

				INITIAL DATE	82/02/10	82/04/06	82/06/17	82/08/18	82/08/19	82/10/15	82/10/16	82/10/17
				INITIAL TIME-DEPTH-BOTTOM	1200 0001	1530 0001	1430 0001	0830	0830 0001	1350	0930	0930 0001
00010	WATER	TEMP	CENT		8.0	16.0	27.5		24.0			12.4
00011	WATER	TEMP	FAHN		46.4	60.8	81.5		75.2			54.3
00020	AIR	TEMP	CENT			20.0	38.0		28.0			25.0
00061	STREAM	FLOW,	INST-CFS			7	0	0			0	
00094	CNDUCTVY	FIELD	MICROMHO		350	210	650		910			760
00095	CNDUCTVY	AT 25C	MICROMHO		362	224	625		633			740
00116	INTNSVE	SURVEY	IDENT		820401	820401	820401		820401			820401
00300	DO		MG/L		10.6	9.2	9.3		7.9			12.1
00301	DO	SATUR	PERCENT		89.1	92.0	117.7		92.9			112.0
00400	PH		SU		8.30	8.40	7.80		8.40			7.88
00403	LAB	PH	SU		8.1	8.2	7.9		8.0			8.3
00410	T ALK	CACO3	MG/L		124	68	161		193			200
00415	PHEN-PH-	LFIN ALK	MG/L		0	0	0		0			0 U
00500	RESIDUE	TOTAL	MG/L		234	142	386		379			440
00530	RESIDUE	TOT NFLT	MG/L		1 K	4	1		15			8
00625	TOT KJEL	N	MG/L		0.200 K	0.600	0.600		0.100 K			0.900
00665	PHOS-TOT		MG/L P		0.050	0.050	0.050 K		0.440			0.070
00671	PHOS-DIS	ORTHO	MG/L P			0.015	0.010 K		0.240			0.010 K
00900	TOT HARD	CACO3	MG/L		108	70	172		199			180
00916	CALCIUM	CA-TOT	MG/L		32.0	19.0	41.0		44.2			40.0
00927	MGNSIUM	MG,TOT	MG/L		7.0	5.0	17.0		21.2			19.0
00929	SODIUM	NA,TOT	MG/L		30.00	14.00	72.00		68.00			94.40
00937	PTSSIUM	K,TOT	MG/L		4.00	2.30	7.00		7.30			6.90
00940	CHLORIDE	TOTAL	MG/L		10	5	24		23			29
00945	SULFATE	SO4-TOT	MG/L		30	15	97		71			88
00951	FLUORIDE	F,TOTAL	MG/L		1.89	1.10	2.12		3.02			3.44
01000	ARSENIC	AS,DISS	UG/L			20 K	30		39			25
01002	ARSENIC	AS,TOT	UG/L		30	20 K	0		38			26
01025	CADMIUM	CD,DISS	UG/L			5 K	5 K		5 K			5 K
01027	CADMIUM	CD,TOT	UG/L		5 K	5 K	5 K		5 K			5 K
01030	CHROMIUM	CR,DISS	UG/L			50 K	10 K		10 K			10 K
01034	CHROMIUM	CR,TOT	UG/L		50 K	50 K	10 K		10 K			10 K
01040	COPPER	CU,DISS	UG/L			50 K			10 K			10 K
01042	COPPER	CU,TOT	UG/L		50 K	50 K	50 K		10			17
01045	IRON	FE,TOT	UG/L		430	60	100 K		220			180
01046	IRON	FE,DISS	UG/L			50 K			10 K			100 K
01049	LEAD	PB,DISS	UG/L			20 K	20 K		20 K			20 K
01051	LEAD	PB,TOT	UG/L		20 K	20 K	20 K		20 K			20 K
01055	MANGNESE	MN	UG/L		190.0	60.0	180.0		340.0			160.0
01056	MANGNESE	MN,DISS	UG/L			0.1			290.0			70.0
01060	MOLY	MO,DISS	UG/L			15	28		29	14		40
01062	MOLY	MO,TOT	UG/L		10 K	17	10 K		38	14		40
01075	SILVER	AG,DISS	UG/L			50.0 K	5.0 K		5.0 K			5.0 K
01077	SILVER	AG,TOT	UG/L		50.0 K	50.0 K	5.0 K		5.0 K			5.0 K
01090	ZINC	ZN,DISS	UG/L			50 K			50 K			50 K

(SAMPLE CONTINUED ON NEXT PAGE)

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 10671200000798 BC027        T15NR9WS29AB
34 37 10.0 113 13 06.0  2
BOULDER CR BELOW BUTTE CR
04025 ARIZONA             YAVAPAI
COLORADO RIVER             110100
LOWER COLORADO RIVER
21ARIZ
       820227     DEPTH     1
/TYPA/AMBNT/STREAM
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(SAMPLE CONTINUED FROM PREVIOUS PAGE)

INITIAL DATE				82/02/10	82/04/06	82/06/17	82/08/18	82/08/19	82/10/15	82/10/16	82/10/17
INITIAL TIME-DEPTH-BOTTOM				1200 0001	1530 0001	1430 0001	0830	0830 0001	1350	0930	0930 0001
01092	ZINC	ZN,TOT	UG/L	120	50 K	210		50 K			50 K
01095	ANTIMONY	SB,DISS	UG/L		10 K	10 K		10 K	10 K		10 K
01097	ANTIMONY	SB,TOT	UG/L	10 K	10 K	10 K		12	10 K		10 K
01145	SELENIUM	SE,DISS	UG/L		5 K	5 K		5 K			5 K
01147	SELENIUM	SE,TOT	UG/L	5 K	5 K	5 K		5 K			5 K
31625	FEC COLI	M-FCAGAD	/100 ML		2 K	2 K		11			2 K
71850	NITRATE	TOT-NO3	MG/L	0.1 K	0.1	0.0		0.2 K			0.4 K
71890	MERCURY	HG,DISS	UG/L		0.5 K	0.5 K		0.0 K			0.5 K
71900	MERCURY	HG,TOTAL	UG/L	2.0 K	0.5 K	0.5 K		0.5 K			0.5 K
82079	TURBIDTY	LAB	NTU	10.0	5.0	2.0		7.0			4.0
82233	SILICON	SI TOTAL	MG/L	13.19	9.60	3.90		18.60			5.20
INITIAL DATE				82/12/12	83/02/16						
INITIAL TIME-DEPTH-BOTTOM					1525						
00010	WATER	TEMP	CENT		8.8						
00011	WATER	TEMP	FAHN		47.8						
00020	AIR	TEMP	CENT		19.0						
00061	STREAM	FLOW,	INST-CFS		14						
00094	CNDUCTVY	FIELD	MICROMHO		149						
00095	CNDUCTVY	AT 25C	MICROMHO	133	150						
00300	DO		MG/L		12.8						
00301	DO	SATUR	PERCENT		110.3						
00400	PH		SU		8.23						
00403	LAB	PH	SU	7.4	7.5						
00410	T ALK	CACO3	MG/L	30	41						
00415	PHEN-PH-	LPIN ALK	MG/L	0	0						
00500	RESIDUE	TOTAL	MG/L	116	121						
00530	RESIDUE	TOT NFLT	MG/L	7	5						
00625	TOT KJEL	N	MG/L	0.700	1.500						
00665	PHOS-TOT		MG/L P	0.060	0.050 K						
00671	PHOS-DIS	ORTHO	MG/L P	0.040	0.030						
00900	TOT HARD	CACO3	MG/L	42	54						
00916	CALCIUM	CA-TOT	MG/L	11.0	14.8						
00927	MGNSIUM	MG,TOT	MG/L	4.0	5.0						
00929	SODIUM	NA,TOT	MG/L	10.00 K	9.20						
00937	PTSSIUM	K,TOT	MG/L	1.80	1.70						
00940	CHLORIDE	TOTAL	MG/L	2	3						
00945	SULFATE	SO4-TOT	MG/L	16	16						
00951	FLUORIDE	F,TOTAL	MG/L	0.82	1.00						
01000	ARSENIC	AS,DISS	UG/L	20 K	20 K						
01002	ARSENIC	AS,TOT	UG/L	20 K	20 K						
01025	CADMIUM	CD,DISS	UG/L	5 K	5 K						
01027	CADMIUM	CD,TOT	UG/L	5 K	5 K						
01030	CHROMIUM	CR,DISS	UG/L	10 K	10 K						
01034	CHROMIUM	CR,TOT	UG/L	10 K	10 K						

(SAMPLE CONTINUED ON NEXT PAGE)

106712000000798 BC027 T15NR9WS29AB
34 37 10.0 113 13 06.0 2
BOULDER CR BELOW BUTTE CR
04025 ARIZONA YAVAPAI
COLORADO RIVER 110100
LOWER COLORADO RIVER
21ARIZ
820227 DEPTH 1
/TYPA/AMBNT/STREAM

(SAMPLE CONTINUED FROM PREVIOUS PAGE)

				INITIAL DATE	82/12/12	83/02/16
				INITIAL TIME-DEPTH-BOTTOM		1525
01040	COPPER	CU,DISS	UG/L		10 K	10 K
01042	COPPER	CU,TOT	UG/L		10 K	10 K
01045	IRON	FE,TOT	UG/L		1980	960
01046	IRON	FE,DISS	UG/L		230	420
01049	LEAD	PB,DISS	UG/L		20 K	20 K
01051	LEAD	PB,TOT	UG/L		20 K	20 K
01055	MANGNESE	MN	UG/L		50.0 K	50.0 K
01056	MANGNESE	MN,DISS	UG/L		50.0 K	50.0 K
01060	MOLY	MO,DISS	UG/L		10 K	10 K
01062	MOLY	MO,TOT	UG/L		10 K	10 K
01075	SILVER	AG,DISS	UG/L		5.0 K	5.0 K
01077	SILVER	AG,TOT	UG/L		5.0 K	5.0 K
01090	ZINC	ZN,DISS	UG/L		50 K	50
01092	ZINC	ZN,TOT	UG/L		50 K	400
01095	ANTIMONY	SB,DISS	UG/L		10 K	10 K
01097	ANTIMONY	SB,TOT	UG/L		10 K	10 K
01145	SELENIUM	SE,DISS	UG/L		5 K	5 K
01147	SELENIUM	SE,TOT	UG/L		5 K	5 K
01501	ALPHA	TOTAL	PC/L			3
01502	ALPHA-T	ERROR	PC/L			1
03501	BETA	TOTAL	PC/L			3 K
22708	U-NAT	TOTAL	MG/L			0.003
31613	FEC COLI	M-FCAGAR	/100ML		10	3 K
71850	NITRATE	TOT-NO3	MG/L		0.4 K	0.4 K
71890	MERCURY	HG,DISS	UG/L		0.5 K	0.5 K
71900	MERCURY	HG,TOTAL	UG/L		0.5 K	0.5 K
82079	TURBIDTY	LAB	NTU		28.0	10.0
82233	SILICON	SI TOTAL	MG/L		15.20	10.40

STORET RETRIEVAL DATE 83/09/09
10671200000930 BC027.9
34 37 50.0 113 12 51.0 2
BOULDER CR BELOW LOWER HILLSIDE TAILINGS
04025 ARIZONA YAVAPAI
COLORADO RIVER 110100
LOWER COLORADO RIVER
21ARIZ
830205 DEPTH 1
/TYPA/AMBNT/STREAM

	INITIAL DATE			82/10/15	
	INITIAL TIME-DEPTH-BOTTOM			1350 0001	
00010	WATER	TEMP	CENT	16.4	
00011	WATER	TEMP	FAHN	61.5	
00020	AIR	TEMP	CENT	30.0	
00094	CNDUCTVY	FIELD	MICROMHO	1720	
00095	CNDUCTVY	AT 25C	MICROMHO	1639	
00116	INTNSVE	SURVEY	IDENT	820401	
00300	DO		MG/L	12.0	
00301	DO	SATUR	PERCENT	120.0	
00400	PH		SU	7.75	
00403	LAB	PH	SU	7.4	
00410	T ALK	CACO3	MG/L	184	
00415	PHEN-PH-	LPIN ALK	MG/L	0	U
00500	RESIDUE	TOTAL	MG/L	270	
00530	RESIDUE	TOT NFLT	MG/L	8	
00625	TOT KJEL	N	MG/L	0.750	
00665	PHOS-TOT		MG/L P	0.050	K
00900	TOT HARD	CACO3	MG/L	640	
00916	CALCIUM	CA-TOT	MG/L	139.0	
00927	MGNSIUM	MG,TOT	MG/L	70.0	
00929	SODIUM	NA,TOT	MG/L	160.20	
00937	PTSSIUM	K,TOT	MG/L	11.80	
00940	CHLORIDE	TOTAL	MG/L	49	
00945	SULFATE	SO4-TOT	MG/L	649	
00951	FLUORIDE	F,TOTAL	MG/L	6.40	
01002	ARSENIC	AS,TOT	UG/L	41	
01027	CADMIUM	CD,TOT	UG/L	6	
01034	CHROMIUM	CR,TOT	UG/L	10	K
01042	COPPER	CU,TOT	UG/L	17	
01045	IRON	FE,TOT	UG/L	100	
01051	LEAD	PB,TOT	UG/L	20	K
01055	MANGNESE	MN	UG/L	23200.0	
01062	MOLY	MO,TOT	UG/L	0	
01077	SILVER	AG,TOT	UG/L	5.0	K
01092	ZINC	ZN,TOT	UG/L	7600	
01097	ANTIMONY	SB,TOT	UG/L	0	K
01147	SELENIUM	SE,TOT	UG/L	5	K
71850	NITRATE	TOT-NO3	MG/L	0.1	
71900	MERCURY	HG,TOTAL	UG/L	0.5	K
82079	TURBIDTY	LAB	NTU	1.5	
82233	SILICON	SI TOTAL	MG/L	13.40	

106712000000991 BC028 T15NR9WS21BB
34 38 02.0 113 12 41.0 2
BOULDER CR BELOW MID HILLSIDE
04025 ARIZONA YAVAPAI
COLORADO RIVER 110100
LOWER COLORADO RIVER
21ARIZ
820227 DEPTH 1
/TYPA/AMBNT/STREAM

	INITIAL DATE			82/02/10	82/04/06	82/10/15	82/12/12
	INITIAL TIME-DEPTH-BOTTOM			1530	1300 0001	1250	1100
00010	WATER	TEMP	CENT		15.0		5.5
00011	WATER	TEMP	FAHN		59.0		41.9
00020	AIR	TEMP	CENT		20.0		22.0
00094	CNDUCTVY	FIELD	MICROMHO		190		98
00095	CNDUCTVY	AT 25C	MICROMHO	377	216		120
00116	INTNSVE	SURVEY	IDENT		820401	820401	
00300	DO		MG/L		9.3		2.0
00301	DO	SATUR	PERCENT		91.2		16.0
00400	PH		SU		8.30		7.28
00403	LAB	PH	SU	8.1	8.0		7.3
00410	T ALK	CACO3	MG/L	134	64		28
00415	PHEN-PH-	LFIN ALK	MG/L	0	0		0
00500	RESIDUE	TOTAL	MG/L	235	141		102
00530	RESIDUE	TOT NFLT	MG/L	1	4		7
00625	TOT KJEL	N	MG/L	0.200 K	0.200 K		0.700
00665	PHOS-TOT		MG/L P	0.040	0.050 K		0.050 K
00671	PHOS-DIS	ORTHO	MG/L P		0.010 K		
00900	TOT HARD	CACO3	MG/L	112	70		36
00916	CALCIUM	CA-TOT	MG/L	32.0	19.0		11.0
00927	MGNSIUM	MG,TOT	MG/L	8.0	5.0		2.0
00929	SODIUM	NA,TOT	MG/L	32.00	14.00		10.00 K
00937	PTSSIUM	K,TOT	MG/L	3.00	2.30		1.80
00940	CHLORIDE	TOTAL	MG/L	12	5		2
00945	SULFATE	SO4-TOT	MG/L	28	14		15
00951	FLUORIDE	F,TOTAL	MG/L	1.82	1.20		0.81
01000	ARSENIC	AS,DISS	UG/L		20 K		
01002	ARSENIC	AS,TOT	UG/L	45	20 K		20 K
01025	CADMIUM	CD,DISS	UG/L		5 K		
01027	CADMIUM	CD,TOT	UG/L	5 K	5 K		5 K
01030	CHROMIUM	CR,DISS	UG/L		50 K		
01034	CHROMIUM	CR,TOT	UG/L	50 K	50 K		10 K
01040	COPPER	CU,DISS	UG/L		50 K		
01042	COPPER	CU,TOT	UG/L	50 K	50 K		10 K
01045	IRON	FE,TOT	UG/L	570	100		1980
01046	IRON	FE,DISS	UG/L		50 K		
01049	LEAD	PB,DISS	UG/L		20 K		
01051	LEAD	PB,TOT	UG/L	20 K	20 K		20 K
01055	MANGNESE	MN	UG/L	340.0	120.0		50.0 K
01056	MANGNESE	MN,DISS	UG/L		110.0		
01060	MOLY	MO,DISS	UG/L		15		
01062	MOLY	MO,TOT	UG/L	10 K	10 K		10 K
01075	SILVER	AG,DISS	UG/L		50.0 K		
01077	SILVER	AG,TOT	UG/L	50.0 K	50.0 K		5.0 K
01090	ZINC	ZN,DISS	UG/L		70		
01092	ZINC	ZN,TOT	UG/L	130	50 K		50 K

(SAMPLE CONTINUED ON NEXT PAGE)

STORET RETRIEVAL DATE 83/09/09
10671200000991 BC028 T15NR9WS21BB
34 38 02.0 113 12 41.0 2
BOULDER CR BELOW MID HILLSIDE
04025 ARIZONA YAVAPAI
COLORADO RIVER 110100
LOWER COLORADO RIVER
21ARIZ
820227 DEPTH 1
/TYPA/AMBNT/STREAM

(SAMPLE CONTINUED FROM PREVIOUS PAGE)

	INITIAL DATE			82/02/10	82/04/06	82/10/15	82/12/12
	INITIAL TIME-DEPTH-BOTTOM			1530	1300 0001	1250	1100
01095	ANTIMONY	SB,DISS	UG/L		10 K		
01097	ANTIMONY	SB,TOT	UG/L	0 K	10 K		10 K
01145	SELENIUM	SE,DISS	UG/L		5 K		
01147	SELENIUM	SE,TOT	UG/L	5 K	5 K		5 K
31625	FEC COLI	M-FCAGAD	/100 ML		2		
71850	NITRATE	TOT-NO3	MG/L	0.1 K	0.0		0.4 K
71890	MERCURY	HG,DISS	UG/L		0.5 K		
71900	MERCURY	HG,TOTAL	UG/L	2.0 K	0.5 K		0.5 K
82079	TURBIDTY	LAB	NTU	7.0	5.0		28.0
82233	SILICON	SI TOTAL	MG/L	13.74	9.60		15.20

STORET RETRIEVAL DATE 83/09/09
10671200000992 BC026.0
34 38 02.0 113 12 41.0 2
BOULDER CR BELOW MID-HILLSIDE ADIT
04025 ARIZONA YAVAPAI
COLORADO RIVER 110100
LOWER COLORADO RIVER
21ARIZ
830205 DEPTH 1
/TYPA/AMBNT/STREAM

	INITIAL DATE			82/06/17		82/08/18		82/10/15		83/02/16	
	INITIAL TIME-DEPTH-BOTTOM			1140 0001		1230 0001		1250		1230	
00010	WATER	TEMP	CENT	29.5		29.5				7.2	
00011	WATER	TEMP	FAHN	85.1		85.1				45.0	
00020	AIR	TEMP	CENT	38.0		42.0				21.0	
00094	CNDUCTVY	FIELD	MICROMHO	1150		3000				144	
00095	CNDUCTVY	AT 25C	MICROMHO	1190		1887		2174		151	
00116	INTNSVE	SURVEY	IDENT	820401		820401					
00300	DO		MG/L	6.8		6.0				11.7	
00301	DO	SATUR	PERCENT	89.5		78.9				95.9	
00400	PH		SU	7.30		6.60				8.27	
00403	LAB	PH	SU	6.9		6.7		6.7		7.5	
00410	T ALK	CACO3	MG/L	158		117		123		39	
00415	PHEN-PH-	LPIN ALK	MG/L	0		0		0		0	
00500	RESIDUE	TOTAL	MG/L	960		1666		2162		131	
00530	RESIDUE	TOT NFLT	MG/L	14		24		40		1	
00625	TOT KJEL	N	MG/L			0.100	K	2.400		0.700	
00665	PHOS-TOT		MG/L P	0.050	K	0.440		0.050	K	0.050	
00900	TOT HARD	CACO3	MG/L	552		1052		1330		52	
00916	CALCIUM	CA-TOT	MG/L	133.0		228.5		316.0		15.0	
00927	MGNSIUM	MG,TOT	MG/L	53.0		100.9		130.0		4.0	
00929	SODIUM	NA,TOT	MG/L	84.00		115.00		123.20		8.70	
00937	PTSSIUM	K,TOT	MG/L	0.31		11.40		11.40		1.50	
00940	CHLORIDE	TOTAL	MG/L	27		33		29		3	
00945	SULFATE	SO4-TOT	MG/L	485		971		1294		12	
00951	FLUORIDE	F,TOTAL	MG/L	2.81		5.10		5.45		0.94	
01002	ARSENIC	AS,TOT	UG/L	1200		840		320		20	K
01027	CADMIUM	CD,TOT	UG/L	5	K	5	K	5	K	5	K
01034	CHROMIUM	CR,TOT	UG/L	10	K	10	K	10	K	10	K
01042	COPPER	CU,TOT	UG/L	50	K	10	K	11		10	K
01045	IRON	FE,TOT	UG/L	11500		8930		16700		1000	
01051	LEAD	PB,TOT	UG/L	20	K	20	K	20	K	20	K
01055	MANGNESE	MN	UG/L	18700.0		24300.0		30000.0			
01062	MOLY	MO,TOT	UG/L	29		15		14		10	K
01077	SILVER	AG,TOT	UG/L	5.0	K	5.0	K	5.0	K	5.0	K
01092	ZINC	ZN,TOT	UG/L	3600		4140		3450		50	K
01097	ANTIMONY	SB,TOT	UG/L	10		10	K	10	K	10	K
01147	SELENIUM	SE,TOT	UG/L	5	K	5	K	5	K	5	K
01501	ALPHA	TOTAL	PC/L							2	K
03501	BETA	TOTAL	PC/L							3	K
22708	U-NAT	TOTAL	MG/L							0.003	
71850	NITRATE	TOT-NO3	MG/L	0.0		0.2	K	0.4	K	0.4	K
71900	MERCURY	HG,TOTAL	UG/L	0.5	K	0.5	K	0.5	K	0.5	K
82079	TURBIDTY	LAB	NTU	1200.0		90.0		125.0		10.0	
82233	SILICON	SI TOTAL	MG/L	5.60		13.40		14.30		9.90	

STORET RETRIEVAL DATE 83/09/09
106712000000993 BC028.1
34 38 02.0 113 12 41.0 2
BOULDER CR ABOVE MID-HILLSIDE ADIT
04025 ARIZONA YAVAPAI
COLORADO RIVER 110100
LOWER COLORADO RIVER
21ARIZ
830205 DEPTH 1
/TYPA/AMBNT/STREAM

	INITIAL DATE			82/06/17	82/08/18	82/10/15	83/02/16
	INITIAL TIME-DEPTH-BOTTOM			1140 0001	1230 0001	1240	1235
00010	WATER	TEMP	CENT	27.5	30.0	17.0	7.0
00011	WATER	TEMP	FAHN	81.5	86.0	62.6	44.6
00020	AIR	TEMP	CENT	38.0	42.0	30.0	21.0
00094	CNDUCTVY	FIELD	MICROMHO	600	1370	1275	142
00095	CNDUCTVY	AT 25C	MICROMHO	565	1075	1204	149
00116	INTNSVE	SURVEY	IDENT	820401	820401	820401	
00300	DO		MG/L	9.8	7.3	11.0	12.0
00301	DO	SATUR	PERCENT	124.1	96.1	113.4	98.4
00400	PH		SU	8.40	6.70	8.78	8.27
00403	LAB	PH	SU	8.4	7.2	8.3	7.6
00410	T ALK	CACO3	MG/L	186	158	218	39
00415	PHEN-PH-	LPIN ALK	MG/L	2	0	0	0
00500	RESIDUE	TOTAL	MG/L	334	735	802	125
00530	RESIDUE	TOT NFLT	MG/L	3	4	2	1 K
00625	TOT KJEL	N	MG/L	0.450	0.100 K	1.100	9.000
00665	PHOS-TOT		MG/L P	0.050 K	0.300	0.050 K	0.050 K
00671	PHOS-DIS	ORTHO	MG/L P			0.010 K	
00900	TOT HARD	CACO3	MG/L	142	361	356	50
00916	CALCIUM	CA-TOT	MG/L	27.0	54.8	69.0	14.0
00927	MGNSIUM	MG,TOT	MG/L	18.0	39.7	44.0	3.0
00929	SODIUM	NA,TOT	MG/L	72.00	101.00	147.40	8.70
00937	PTSSIUM	K,TOT	MG/L	7.00	9.80	11.20	1.50
00940	CHLORIDE	TOTAL	MG/L	28	42	60	3
00945	SULFATE	SO4-TOT	MG/L	39	335	288	11
00951	FLUORIDE	F,TOTAL	MG/L	2.20	4.19	4.08	0.92
01000	ARSENIC	AS,DISS	UG/L			20 K	
01002	ARSENIC	AS,TOT	UG/L	30	20 K	20 K	20 K
01025	CADMIUM	CD,DISS	UG/L			5 K	
01027	CADMIUM	CD,TOT	UG/L	5 K	12	5 K	5 K
01030	CHROMIUM	CR,DISS	UG/L			10 K	
01034	CHROMIUM	CR,TOT	UG/L	10 K	10 K	10 K	10 K
01040	COPPER	CU,DISS	UG/L			10 K	
01042	COPPER	CU,TOT	UG/L	50 K	10 K	15	10 K
01045	IRON	FE,TOT	UG/L	100 K	100 K	100 K	1000
01046	IRON	FE,DISS	UG/L			100 K	
01049	LEAD	PB,DISS	UG/L			20 K	
01051	LEAD	PB,TOT	UG/L	20 K	20 K	20 K	20 K
01055	MANGNESE	MN	UG/L	370.0	24300.0	4350.0	50.0 K
01056	MANGNESE	MN,DISS	UG/L			4150.0	
01060	MOLY	MO,DISS	UG/L			17	
01062	MOLY	MO,TOT	UG/L	10 K	19	10 K	10 K
01075	SILVER	AG,DISS	UG/L			5.0 K	
01077	SILVER	AG,TOT	UG/L	5.0 K	5.0 K	5.0 K	5.0 K
01090	ZINC	ZN,DISS	UG/L			1400	
01092	ZINC	ZN,TOT	UG/L	280	10960	1620	50 K

(SAMPLE CONTINUED ON NEXT PAGE)

STORET RETRIEVAL DATE 83/09/09
10671200000993 BC028.1
34 38 02.0 113 12 41.0 2
BOULDER CR ABOVE MID-HILLSIDE ADIT
04025 ARIZONA YAVAPAI
COLORADO RIVER 110100
LOWER COLORADO RIVER
21ARIZ
830205 DEPTH 1
/TYPA/AMBNT/STREAM

(SAMPLE CONTINUED FROM PREVIOUS PAGE)

INITIAL DATE				82/06/17	82/08/18	82/10/15	83/02/16
INITIAL TIME-DEPTH-BOTTOM				1140 0001	1230 0001	1240	1235
01095	ANTIMONY	SB,DISS	UG/L		11	10 K	
01097	ANTIMONY	SB,TOT	UG/L	10 K		10 K	10 K
01145	SELENIUM	SE,DISS	UG/L			5 K	
01147	SELENIUM	SE,TOT	UG/L	5 K	5 K	5 K	5 K
01501	ALPHA	TOTAL	PC/L				2 K
03501	BETA	TOTAL	PC/L				3 K
22708	U-NAT	TOTAL	MG/L				0.003
31625	FEC COLI	M-FCAGAD	/100 ML			2 K	
71850	NITRATE	TOT-NO3	MG/L	0.2	0.2 K	0.4 K	0.4 K
71890	MERCURY	HG,DISS	UG/L			0.5 K	
71900	MERCURY	HG,TOTAL	UG/L	0.5 K	0.5 K	0.5 K	0.5 K
82079	TURBIDTY	LAB	NTU	3.0	3.0	1.0	10.0
82233	SILICON	SI TOTAL	MG/L	1.00	6.60	8.10	10.40

106712000000994 BC028.2
34 38 02.0 113 12 41.0 2
ADIT SEEP AT MID-HILLSIDE
04025 ARIZONA YAVAPAI
COLORADO RIVER 110100
LOWER COLORADO RIVER
21ARIZ
830205 DEPTH 1
/TYPA/AMBNT/STREAM

	INITIAL DATE			82/06/17		82/08/18		82/10/15		83/02/16
	INITIAL TIME-DEPTH-BOTTOM			1140 0001		1230 0001		1230 0001		1240
00010	WATER	TEMP	CENT	22.5		22.0		21.0		17.5
00011	WATER	TEMP	FAHN	72.5		71.6		69.8		63.5
00020	AIR	TEMP	CENT	38.0		42.0		30.0		22.0
00094	CNDUCTVY	FIELD	MICROMHO	1850		3100		1880		2950
00095	CNDUCTVY	AT 25C	MICROMHO	2127		2222		2222		1818
00116	INTNSVE	SURVEY	IDENT	820401		820401		820401		
00300	DO		MG/L	0.9		0.5		4.9		4.6
00301	DO	SATUR	PERCENT	10.3		5.7		54.4		48.9
00400	PH		SU	6.00		5.40		6.21		6.25
00403	LAB	PH	SU	5.9		6.2		6.2		7.5
00410	T ALK	CACO3	MG/L	0		145		0	U	72
00415	PHEN-PH-	LPIN ALK	MG/L	0		0		0	U	0
00500	RESIDUE	TOTAL	MG/L	378		2636		2256		2242
00530	RESIDUE	TOT NFLT	MG/L	34		108		96		96
00625	TOT KJEL	N	MG/L	0.050		0.100	K	0.860		0.700
00665	PHOS-TOT		MG/L P	0.050		0.620		0.050	K	0.070
00900	TOT HARD	CACO3	MG/L	1450		1587		1430		1440
00916	CALCIUM	CA-TOT	MG/L	249.0		331.8		336.0		372.0
00927	MGNSIUM	MG,TOT	MG/L	138.0		146.2		142.0		122.0
00929	SODIUM	NA,TOT	MG/L	90.00		92.00		94.40		92.50
00937	PTSSIUM	K,TOT	MG/L	9.00		10.70		10.00		9.70
00940	CHLORIDE	TOTAL	MG/L	23		24		22		22
00945	SULFATE	SO4-TOT	MG/L	1434		1429		1485		1399
00951	FLUORIDE	F,TOTAL	MG/L	5.09		6.15		6.31		5.00
01002	ARSENIC	AS,TOT	UG/L	20600		7800		6200		4640
01027	CADMIUM	CD,TOT	UG/L	5	K	5	K	5	K	5 K
01034	CHROMIUM	CR,TOT	UG/L	10	K	10	K	10	K	10 K
01042	COPPER	CU,TOT	UG/L	50	K	10	K	13		10 K
01045	IRON	FE,TOT	UG/L	68000		47300		55500		46300
01051	LEAD	PB,TOT	UG/L	20	K	20	K	20	K	20 K
01055	MANGNESE	MN	UG/L	45000.0		35900.0		41900.0		36900.0
01062	MOLY	MO,TOT	UG/L	64		44		25		10 K
01077	SILVER	AG,TOT	UG/L	5.0	K	5.0	K	5.0	K	5.0 K
01092	ZINC	ZN,TOT	UG/L	9500		4720		5400		4500
01097	ANTIMONY	SB,TOT	UG/L	22		15		10	K	10 K
01147	SELENIUM	SE,TOT	UG/L	5	K	5	K	5	K	5 K
01501	ALPHA	TOTAL	PC/L							657
01502	ALPHA-T	ERROR	PC/L							48
03501	BETA	TOTAL	PC/L							282
03502	BETA-T	ERROR	PC/L							9
09501	RA-226	TOTAL	PC/L							61.8
09502	RA-226	ERROR	PC/L							4.2
11501	RA-228	TOTAL	PC/L							2.0 K
22707	U-NAT	SEDIMENT	UG/G							1.0
71850	NITRATE	TOT-NO3	MG/L	0.1		0.2		0.4	K	1.8

(SAMPLE CONTINUED ON NEXT PAGE)

STORET RETRIEVAL DATE 83/09/09
106712000000994 BC028.2
34 38 02.0 113 12 41.0 2
ADIT SEEP AT MID-HILLSIDE
04025 ARIZONA YAVAPAI
COLORADO RIVER 110100
LOWER COLORADO RIVER
21ARIZ
830205 DEPTH 1
/TYPA/AMBNT/STREAM

(SAMPLE CONTINUED FROM PREVIOUS PAGE)

INITIAL DATE			82/06/17	82/08/18	82/10/15	83/02/16
INITIAL TIME-DEPTH-BOTTOM			1140 0001	1230 0001	1230 0001	1240
71900	MERCURY	HG,TOTAL UG/L	0.5 K	0.5 K	0.5 K	0.5 K
82079	TURBIDTY	LAB NTU	90.0	120.0	120.0	67.0
82233	SILICON	SI TOTAL MG/L	15.40	19.10	16.70	15.20

STORET RETRIEVAL DATE 83/09/09
 10671200000 1050 BC028.23
34 38 22.0 113 12 37.0 2
BOULDER CR 1/2 MI BELOW HILLSIDE FORD
04025 ARIZONA YAVAPAI
COLORADO RIVER 110100
LOWER COLORADO RIVERS00000000
21ARIZ
 830205 DEPTH 1
/TYPA/AMBNT/STREAM

	INITIAL DATE			82/10/15	
	INITIAL TIME-DEPTH-BOTTOM			1140 0001	
00010	WATER	TEMP	CENT	15.0	
00011	WATER	TEMP	FAHN	59.0	
00020	AIR	TEMP	CENT	30.0	
00095	CNDUCTVY	AT 25C	MICROMHO	2083	
00400	PH		SU	7.38	
00403	LAB	PH	SU	7.5	
00410	T ALK	CACO3	MG/L	74	
00415	PHEN-PH-	LFIN ALK	MG/L	0	U
00500	RESIDUE	TOTAL	MG/L	1904	
00530	RESIDUE	TOT NFLT	MG/L	7	
00625	TOT KJEL	N	MG/L	0.740	
00665	PHOS-TOT		MG/L P	0.050	K
00900	TOT HARD	CACO3	MG/L	920	
00916	CALCIUM	CA-TOT	MG/L	203.0	
00927	MGNSIUM	MG,TOT	MG/L	99.0	
00929	SODIUM	NA,TOT	MG/L	197.10	
00937	PTSSIUM	K,TOT	MG/L	14.60	
00940	CHLORIDE	TOTAL	MG/L	43	
00945	SULFATE	SO4-TOT	MG/L	1168	
00951	FLUORIDE	F,TOTAL	MG/L	5.25	
01002	ARSENIC	AS,TOT	UG/L	20	K
01027	CADMIUM	CD,TOT	UG/L	8	
01034	CHROMIUM	CR,TOT	UG/L	10	K
01037	COBALT	CO,TOTAL	UG/L	90	
01042	COPPER	CU,TOT	UG/L	97	
01045	IRON	FE,TOT	UG/L	260	
01051	LEAD	PB,TOT	UG/L	20	K
01055	MANGNESE	MN	UG/L	2700.0	
01062	MOLY	MO,TOT	UG/L	10	K
01067	NICKEL	NI,TOTAL	UG/L	300	K
01077	SILVER	AG,TOT	UG/L	5.0	K
01092	ZINC	ZN,TOT	UG/L	9600	
01097	ANTIMONY	SB,TOT	UG/L	10	K
01105	ALUMINUM	AL,TOT	UG/L	500	K
01132	LITHIUM	LI,TOT	UG/L	300	
01147	SELENIUM	SE,TOT	UG/L	5	K
71850	NITRATE	TOT-NO3	MG/L	0.4	K
71900	MERCURY	HG,TOTAL	UG/L	0.5	K
82079	TURBIDTY	LAB	NTU	2.5	
82233	SILICON	SI TOTAL	MG/L	9.00	

STORET RETRIEVAL DATE 83/09/09.
106712000001116 BC028.25
34 38 23.0 113 12 20.0 2
BOULDER CR 2ND POOL BELOW HILLSIDE FORD
04025 ARIZONA YAVAPAI
COLORADO RIVER 110100
LOWER COLORADO RIVER
21ARIZ
830205 DEPTH 1
/TYPA/AMBNT/STREAM

	INITIAL DATE			82/10/15	
	INITIAL TIME-DEPTH-BOTTOM			1040 0001	
00010	WATER	TEMP	CENT	14.0	
00011	WATER	TEMP	FAHN	57.2	
00020	AIR	TEMP	CENT	30.0	
00094	CNDUCTVY	FIELD	MICROMHO	3000	
00095	CNDUCTVY	AT 25C	MICROMHO	2439	
00116	INTNSVE	SURVEY	IDENT	820401	
00400	PH		SU	4.82	
00403	LAB	PH	SU	4.7	
00410	T ALK	CACO3	MG/L	0	U
00415	PHEN-PH-	LPIN ALK	MG/L	0	U
00435	T ACDITY	CACO3	MG/L	225	
00500	RESIDUE	TOTAL	MG/L	2582	
00530	RESIDUE	TOT NFLT	MG/L	5	
00625	TOT KJEL	N	MG/L	0.430	
00665	PHOS-TOT		MG/L P	0.050	K
00900	TOT HARD	CACO3	MG/L	1151	
00916	CALCIUM	CA-TOT	MG/L	258.0	
00927	MGNSIUM	MG,TOT	MG/L	123.0	
00929	SODIUM	NA,TOT	MG/L	183.60	
00937	PTSSIUM	K,TOT	MG/L	16.00	
00940	CHLORIDE	TOTAL	MG/L	50	
00945	SULFATE	SO4-TOT	MG/L	1644	
00951	FLUORIDE	F,TOTAL	MG/L	6.15	
01002	ARSENIC	AS,TOT	UG/L	20	K
01027	CADMIUM	CD,TOT	UG/L	9	
01034	CHROMIUM	CR,TOT	UG/L	10	K
01037	COBALT	CO,TOTAL	UG/L	240	
01042	COPPER	CU,TOT	UG/L	8900	
01045	IRON	FE,TOT	UG/L	150	
01051	LEAD	PB,TOT	UG/L	20	K
01055	MANGNESE	MN	UG/L	24400.0	
01062	MOLY	MO,TOT	UG/L	19	
01067	NICKEL	NI,TOTAL	UG/L	300	K
01077	SILVER	AG,TOT	UG/L	5.0	K
01092	ZINC	ZN,TOT	UG/L	65000	
01097	ANTIMONY	SB,TOT	UG/L	20	
01105	ALUMINUM	AL,TOT	UG/L	11700	
01132	LITHIUM	LI,TOT	UG/L	370	
01147	SELENIUM	SE,TOT	UG/L	5	K
71850	NITRATE	TOT-NO3	MG/L	0.4	K
71900	MERCURY	HG,TOTAL	UG/L	0.5	K
82079	TURBIDTY	LAB	NTU	2.0	
82233	SILICON	SI TOTAL	MG/L	17.20	

STORET RETRIEVAL DATE 83/09/09
10671200001118 BC028.3
34 38 22.0 113 12 19.0 2
BOULDER CR 1ST POOL BELOW HILLSIDE FORD
04025 ARIZONA YAVAPAI
COLORADO RIVER 110100
LOWER COLORADO RIVER
21ARIZ
830205 DEPTH 1
/TYPA/AMBNT/STREAM

	INITIAL DATE			82/04/06		82/06/17		82/08/18		82/10/15		82/12/12	83/02/16
	INITIAL TIME-DEPTH-BOTTOM			1100 0001		1030 0001		1115 0001		1025 0001		0940	1000
00010	WATER	TEMP	CENT			23.9		28.0		14.0		5.3	5.5
00011	WATER	TEMP	FAHN			75.0		82.4		57.2		41.5	41.9
00020	AIR	TEMP	CENT			38.0		33.0		30.0		20.0	15.0
00094	CNDUCTVY	FIELD	MICROMHO			650		5400		4200		103	145
00095	CNDUCTVY	AT 25C	MICROMHO	198		559		3571		3448		118	150
00116	INTNSVE	SURVEY	IDENT	820401		820401		820401		820401			
00300	DO		MG/L			8.0		6.3				12.4	12.0
00301	DO	SATUR	PERCENT			94.1		79.7				96.9	96.4
00400	PH		SU			7.80				2.87		7.48	9.32
00403	LAB	PH	SU	8.2		7.8		2.7		2.9		7.3	7.4
00410	T ALK	CACO3	MG/L	68		207		0		0		30	39
00415	PHEN-PH-	LFIN ALK	MG/L	0		0		0		0		0	0
00435	T ACDITY	CACO3	MG/L					1150		1235			
00500	RESIDUE	TOTAL	MG/L	132		338		2774		3779		102	123
00530	RESIDUE	TOT NFLT	MG/L	3		3		38		59		7	1
00625	TOT KJEL	N	MG/L	0.200	K	0.500		1.100		1.200		0.800	0.900
00665	PHOS-TOT		MG/L P	0.030	K	0.050	K	0.130		0.050	K	0.050 K	0.050
00671	PHOS-DIS	ORTHO	MG/L P			0.040							0.030
00900	TOT HARD	CACO3	MG/L	66		156		1521		1125		36	50
00916	CALCIUM	CA-TOT	MG/L	18.0		36.0		209.6		205.0		10.0	14.0
00927	MGNSIUM	MG,TOT	MG/L	5.0		16.0		146.3		149.0		3.0	4.0
00929	SODIUM	NA,TOT	MG/L	12.00		67.00		128.00		139.60		10.00 K	8.70
00937	PTSSIUM	K,TOT	MG/L	2.30		6.00		10.40		8.70		1.80	1.70
00940	CHLORIDE	TOTAL	MG/L	5		27		37		49		2	3
00945	SULFATE	SO4-TOT	MG/L	11		16		2235		2398		15	11
00951	FLUORIDE	F,TOTAL	MG/L	1.14		1.78		0.32		10.90		0.81	0.98
01000	ARSENIC	AS,DISS	UG/L	20	K	26		720		157		20 K	20 K
01002	ARSENIC	AS,TOT	UG/L	20	K	40		910		550		20 K	20 K
01025	CADMIUM	CD,DISS	UG/L	5	K	5	K	5	K	14		5 K	5 K
01027	CADMIUM	CD,TOT	UG/L	5	K	5	K	37		20		5 K	5 K
01030	CHROMIUM	CR,DISS	UG/L	50	K	10	K	60		77		10 K	10 K
01034	CHROMIUM	CR,TOT	UG/L	50	K	10	K	64		74		10 K	10 K
01035	COBALT	CO,DISS	UG/L							850			
01037	COBALT	CO,TOTAL	UG/L							880			
01040	COPPER	CU,DISS	UG/L	50	K			28800		34160		15	10 K
01042	COPPER	CU,TOT	UG/L	50	K	50	K	24300		37200		10 K	10 K
01045	IRON	FE,TOT	UG/L	50	K	390		75300		108000		1980	1000
01046	IRON	FE,DISS	UG/L	120				69700		108		200	490
01049	LEAD	PB,DISS	UG/L	20	K	20	K	14		20	K	20 K	20 K
01051	LEAD	PB,TOT	UG/L	20	K	20	K	20	K	20	K	20 K	20 K
01055	MANGNESE	MN	UG/L	50.0	K	370.0		35900.0		47900.0		50.0 K	50.0 K
01056	MANGNESE	MN,DISS	UG/L	50.0	K			38800.0		48500.0		50.0 K	50.0 K
01060	MOLY	MO,DISS	UG/L	13		18		83		0		10 K	10 K
01062	MOLY	MO,TOT	UG/L	10	K	13		94		0		10 K	10 K
01065	NICKEL	NI,DISS	UG/L							320			

(SAMPLE CONTINUED ON NEXT PAGE)

STORET RETRIEVAL DATE 83/09/09
10671200000111 8 BC028.3
34 38 22.0 113 12 19.0 2
BOULDER CR 1ST POOL BELOW HILLSIDE FORD
04025 ARIZONA YAVAPAI
COLORADO RIVER 110100
LOWER COLORADO RIVER
21ARIZ
830205 DEPTH 1
/TYPA/AMBNT/STREAM

(SAMPLE CONTINUED FROM PREVIOUS PAGE)

				INITIAL DATE	82/04/06	82/06/17	82/08/18	82/10/15	82/12/12	83/02/16
				INITIAL TIME-DEPTH-BOTTOM	1100 0001	1030 0001	1115 0001	1025 0001	0940	1000
01067	NICKEL	NI,TOTAL	UG/L					320		
01075	SILVER	AG,DISS	UG/L		50.0 K	5.0 K	5.0 K	5.0 K	5.0 K	5.0 K
01077	SILVER	AG,TOT	UG/L		50.0 K	5.0 K	5.0 K	5.0 K	5.0 K	5.0 K
01090	ZINC	ZN,DISS	UG/L		60		133800	195000	50 K	50 K
01092	ZINC	ZN,TOT	UG/L		50 K	770	127200	192500	50 K	50 K
01095	ANTIMONY	SB,DISS	UG/L		10 K	10 K	25	0	10 K	10 K
01097	ANTIMONY	SB,TOT	UG/L		10 K	10 K	29	0	10 K	10 K
01105	ALUMINUM	AL,TOT	UG/L					91400		
01106	ALUMINUM	AL,DISS	UG/L					91400		
01130	LITHIUM	LI,DISS	UG/L					40		
01132	LITHIUM	LI,TOT	UG/L					370		
01145	SELENIUM	SE,DISS	UG/L		5 K	5 K	5 K	5 K	5 K	5 K
01147	SELENIUM	SE,TOT	UG/L		5 K	5 K	14	5 K	5 K	5 K
01501	ALPHA	TOTAL	PC/L							2 K
03501	BETA	TOTAL	PC/L							3 K
22708	U-NAT	TOTAL	MG/L							0.003
71850	NITRATE	TOT-NO3	MG/L		0.0	0.0	0.9	0.4 K	0.4 K	0.4 K
71890	MERCURY	HG,DISS	UG/L		0.5 K	0.5 K	0.5 K	0.5 K	0.5 K	0.5
71900	MERCURY	HG,TOTAL	UG/L		0.5 K	0.5 K	0.5 K	0.5 K	0.5 K	0.5 K
82079	TURBIDTY	LAB	NTU		3.0	3.0	24.0	48.0	28.0	8.5
82233	SILICON	SI TOTAL	MG/L		18.40	9.60	25.90	30.20	14.70	12.20

STORET RETRIEVAL DATE 83/09/09
10671200000 1119 BC028.4
34 38 22.0 113 12 18.5 2
BOULDR CR S CHANNL @HILLSIDE FORD
04025 ARIZONA YAVAPAI
COLORADO RIVER 110100
LOWER COLORADO RIVER
21ARIZ
830205 DEPTH 1
/TYPA/AMBNT/STREAM

	INITIAL DATE			82/04/06	82/10/15		
	INITIAL TIME-DEPTH-BOTTOM			0001	1025		
00094	CNDUCTVY	FIELD	MICROMHO	225			
00095	CNDUCTVY	AT 25C	MICROMHO	219			
00116	INTNSVE	SURVEY	IDENT	820401			
00403	LAB	PH	SU	6.8			
00410	T ALK	CACO3	MG/L	52			
00415	PHEN-PH-	LPIN ALK	MG/L	0			
00500	RESIDUE	TOTAL	MG/L	145			
00530	RESIDUE	TOT NFLT	MG/L	3			
00625	TOT KJEL	N	MG/L	0.210			
00665	PHOS-TOT		MG/L P	0.040			
00900	TOT HARD	CACO3	MG/L	72			
00916	CALCIUM	CA-TOT	MG/L	20.0			
00927	MGNSIUM	MG,TOT	MG/L	6.0			
00929	SODIUM	NA,TOT	MG/L	12.00			
00937	PTSSIUM	K,TOT	MG/L	2.20			
00940	CHLORIDE	TOTAL	MG/L	6			
00945	SULFATE	SO4-TOT	MG/L	42			
00951	FLUORIDE	F,TOTAL	MG/L	1.23			
01000	ARSENIC	AS,DISS	UG/L	20	K		
01002	ARSENIC	AS,TOT	UG/L	20			
01025	CADMIUM	CD,DISS	UG/L	5	K		
01027	CADMIUM	CD,TOT	UG/L	5	K		
01030	CHROMIUM	CR,DISS	UG/L	50	K		
01034	CHROMIUM	CR,TOT	UG/L	50	K		
01040	COPPER	CU,DISS	UG/L	50			
01042	COPPER	CU,TOT	UG/L	70			
01045	IRON	FE,TOT	UG/L	570			
01046	IRON	FE,DISS	UG/L	50	K		
01049	LEAD	PB,DISS	UG/L	20	K		
01051	LEAD	PB,TOT	UG/L	20	K		
01055	MANGNESE	MN	UG/L	270.0			
01056	MANGNESE	MN,DISS	UG/L	250.0			
01060	MOLY	MO,DISS	UG/L	12		47	
01062	MOLY	MO,TOT	UG/L	10	K	45	
01075	SILVER	AG,DISS	UG/L	50.0	K		
01077	SILVER	AG,TOT	UG/L	50.0	K		
01090	ZINC	ZN,DISS	UG/L	620			
01092	ZINC	ZN,TOT	UG/L	920			
01095	ANTIMONY	SB,DISS	UG/L	10	K	40	
01097	ANTIMONY	SB,TOT	UG/L	10	K	30	
01130	LITHIUM	LI,DISS	UG/L			370	
01145	SELENIUM	SE,DISS	UG/L	5	K		
01147	SELENIUM	SE,TOT	UG/L	5	K		
71850	NITRATE	TOT-NO3	MG/L	0.0			
71890	MERCURY	HG,DISS	UG/L	0.5	K		

(SAMPLE CONTINUED ON NEXT PAGE)

106712000001119 BC028.4
34 38 22.0 113 12 18.5 2
BOULDR CR S CHANNL @HILLSIDE FORD
04025 ARIZONA YAVAPAI
COLORADO RIVER 110100
LOWER COLORADO RIVER
21ARIZ
830205 DEPTH 1
/TYPA/AMBNT/STREAM

(SAMPLE CONTINUED FROM PREVIOUS PAGE)

	INITIAL DATE			82/04/06	82/10/15
	INITIAL TIME-DEPTH-BOTTOM			0001	1025
71900	MERCURY	HG,TOTAL	UG/L	0.5 K	
82079	TURBIDTY	LAB	NTU	9.0	
82233	SILICON	SI TOTAL	MG/L	10.50	

STORET RETRIEVAL DATE 83/09/09
106712000001122 BC028.7
34 38 22.0 113 12 17.5 2
BOULDR CR N CHANNL @ HILLSIDE FRD
04025 ARIZONA YAVAPAI
COLORADO RIVER 110100
LOWER COLORADO RIVER
21ARIZ
830205 DEPTH 1
/TYPA/AMBNT/STREAM

	INITIAL DATE				82/04/06		82/06/17		83/02/16	
	INITIAL TIME-DEPTH-BOTTOM				1100 0001		1030 0001		1040	
00010	WATER	TEMP	CENT				25.1		5.8	
00011	WATER	TEMP	FAHN				77.2		42.4	
00020	AIR	TEMP	CENT				35.0		21.5	
00094	CNDUCTVY	FIELD	MICROMHO				550		141	
00095	CNDUCTVY	AT 25C	MICROMHO		200		568		140	
00116	INTNSVE	SURVEY	IDENT		820401		820401			
00300	DO		MG/L				7.2		12.2	
00301	DO	SATUR	PERCENT				85.7		97.6	
00400	PH		SU				8.00		9.92	
00403	LAB	PH	SU		8.0		8.2		7.5	
00410	T ALK	CACO3	MG/L		66		198		41	
00415	PHEN-PH-	LFIN ALK	MG/L		0		0		0	
00500	RESIDUE	TOTAL	MG/L		127		308		118	
00530	RESIDUE	TOT NFLT	MG/L		1	K	1		3	
00615	NO2-N	TOTAL	MG/L		1.160		0.010	K		
00625	TOT KJEL	N	MG/L		0.270		0.460		1.100	
00665	PHOS-TOT		MG/L P		0.030	K	0.050	K	0.050	K
00671	PHOS-DIS	ORTHO	MG/L P				0.010			
00900	TOT HARD	CACO3	MG/L		66		146		52	
00916	CALCIUM	CA-TOT	MG/L		17.0		34.0		14.0	
00927	MGNSIUM	MG,TOT	MG/L		6.0		14.0		4.0	
00929	SODIUM	NA,TOT	MG/L		12.00		59.00		8.70	
00937	PTSSIUM	K,TOT	MG/L		2.30		6.00		1.60	
00940	CHLORIDE	TOTAL	MG/L		7		28		3	
00945	SULFATE	SO4-TOT	MG/L		15		6		10	
00951	FLUORIDE	F,TOTAL	MG/L		1.16		1.56		0.92	
01000	ARSENIC	AS,DISS	UG/L		20	K	20			
01002	ARSENIC	AS,TOT	UG/L		20	K	20		20	K
01025	CADMIUM	CD,DISS	UG/L		5	K	5	K		
01027	CADMIUM	CD,TOT	UG/L		5	K	5	K	5	K
01030	CHROMIUM	CR,DISS	UG/L		50	K	20			
01034	CHROMIUM	CR,TOT	UG/L		50	K	10	K	10	K
01040	COPPER	CU,DISS	UG/L		50	K				
01042	COPPER	CU,TOT	UG/L		50	K	50	K	10	K
01045	IRON	FE,TOT	UG/L		50	K	100	K	950	
01046	IRON	FE,DISS	UG/L		50	K				
01049	LEAD	PB,DISS	UG/L		20	K	20	K		
01051	LEAD	PB,TOT	UG/L		20	K	20	K	20	K
01055	MANGNESE	MN	UG/L		50.0	K	190.0		50.0	K
01056	MANGNESE	MN,DISS	UG/L		50.0	K				
01060	MOLY	MO,DISS	UG/L		0	K	13			
01062	MOLY	MO,TOT	UG/L		10	K	25		40	
01075	SILVER	AG,DISS	UG/L		50.0	K	5.0	K		
01077	SILVER	AG,TOT	UG/L		50.0	K	5.0	K	5.0	K
01090	ZINC	ZN,DISS	UG/L		50					

(SAMPLE CONTINUED ON NEXT PAGE)

STORET RETRIEVAL DATE 83/09/09
10671200600112Z 6C028.7
34 38 22.0 113 12 17.5 2
BOULDR CR N CHANNL @ HILLSIDE FRD
04025 ARIZONA YAVAPAI
COLORADO RIVER 110100
LOWER COLORADO RIVER
21ARIZ
830205 DEPTH 1
/TYPA/AMBNT/STREAM

(SAMPLE CONTINUED FROM PREVIOUS PAGE)

INITIAL DATE				82/04/06	82/06/17	83/02/16
INITIAL TIME-DEPTH-BOTTOM				1100 0001	1030 0001	1040
01092	ZINC	ZN,TOT	UG/L	50 K	50 K	50 K
01095	ANTIMONY	SB,DISS	UG/L	10 K	10 K	
01097	ANTIMONY	SB,TOT	UG/L	10 K	10 K	10 K
01145	SELENIUM	SE,DISS	UG/L	5 K	5 K	
01147	SELENIUM	SE,TOT	UG/L	5 K	5 K	5 K
71850	NITRATE	TOT-NO3	MG/L	0.0	0.0	0.4 K
71890	MERCURY	HG,DISS	UG/L	0.5 K	0.5 K	
71900	MERCURY	HG,TOTAL	UG/L	0.5 K	0.5 K	0.5 K
82079	TURBIDTY	LAB	NTU	4.0		9.8
82233	SILICON	SI TOTAL	MG/L	10.50	13.70	9.30

10671200000112O BC028A T15NR9WS16CA
34 38 22.0 113 12 18.0 2
HILLSIDE TAILING SEEP
04025 ARIZONA YAVAPAI
COLORADO RIVER 110100
LOWER COLORADO RIVER
21ARIZ
820227 DEPTH 1
/TYPA/AMBNT/STREAM

	INITIAL DATE			82/02/10		82/04/06		82/06/17		82/08/18	82/10/15	82/12/12	83/02/16
	INITIAL TIME-DEPTH-BOTTOM			1500	0001	1100	0001	1030	0001	1045 0001	1015 0001	0850	1030
00010	WATER	TEMP	CENT					28.0				5.2	6.0
00011	WATER	TEMP	FAHN					82.4				41.4	42.8
00020	AIR	TEMP	CENT					35.0				20.0	19.0
00094	CNDUCTVY	FIELD	MICROMHO			4500		5600				108	149
00095	CNDUCTVY	AT 25C	MICROMHO	408		3571		5556		5263	5000	123	161
00116	INTNSVE	SURVEY	IDENT	820401		820401		820401		820401			
00300	DO		MG/L					7.5				12.2	12.4
00301	DO	SATUR	PERCENT					94.9				95.3	99.2
00400	PH		SU					2.50				7.30	9.50
00403	LAB	PH	SU	7.0		2.9		2.6		2.4	2.6	7.1	7.3
00410	T ALK	CACO3	MG/L	108		0		0		0	0 U	30	41
00415	PHEN-PH-	LFIN ALK	MG/L	0		0		0		0	0 U	0	0
00435	T ACDITY	CACO3	MG/L							4243	3526		
00500	RESIDUE	TOTAL	MG/L	320		4687		6500		8550	7300	103	124
00530	RESIDUE	TOT NFLT	MG/L	1190		10		1	K	12	3	7	2
00615	NO2-N	TOTAL	MG/L					0.010	K				
00625	TOT KJEL	N	MG/L	0.200	K					2.350	0.330	0.800	0.900
00665	PHOS-TOT		MG/L P	0.040				0.050	K	0.410	0.050 K	0.050 K	0.050 K
00900	TOT HARD	CACO3	MG/L	122		1454				2712	1442	38	54
00916	CALCIUM	CA-TOT	MG/L	34.0		186.3		93.5		213.4	223.0	10.0	14.0
00927	MGNSIUM	MG,TOT	MG/L	9.0		142.0		251.4		204.5	215.0	3.0	4.0
00929	SODIUM	NA,TOT	MG/L	32.00		11.00		127.00		8.00	28.10	10.00 K	9.20
00937	PTSSIUM	K,TOT	MG/L	3.00		1.00	K	1.00		0.70	0.50 K	1.80	1.70
00940	CHLORIDE	TOTAL	MG/L	12		6		70		9	13	1	3
00945	SULFATE	SO4-TOT	MG/L	650		2807		3960		5239	4619	15	14
00951	FLUORIDE	F,TOTAL	MG/L	2.15		0.11		0.70		0.18	0.31	0.83	1.00
01000	ARSENIC	AS,DISS	UG/L			10900							
01002	ARSENIC	AS,TOT	UG/L	20	K	5500		1700		34010	7140	20 K	20 K
01025	CADMIUM	CD,DISS	UG/L			14							
01027	CADMIUM	CD,TOT	UG/L	8		5		29		5 K	14	5 K	5 K
01030	CHROMIUM	CR,DISS	UG/L			200							
01034	CHROMIUM	CR,TOT	UG/L	50	K	50	K	66		300	167	10 K	
01035	COBALT	CO,DISS	UG/L									10 K	10 K
01037	COBALT	CO,TOTAL	UG/L								2400		
01040	COPPER	CU,DISS	UG/L			52000							
01042	COPPER	CU,TOT	UG/L	290		35000		40000		59100	101100	10 K	10 K
01045	IRON	FE,TOT	UG/L	16000		70000		206000		613200	430000	280	1000
01046	IRON	FE,DISS	UG/L			220000							
01049	LEAD	PB,DISS	UG/L			20	K						
01051	LEAD	PB,TOT	UG/L	20	K	20	K	20	K	20 K	20 K	20 K	20 K
01055	MANGNESE	MN	UG/L	900.0		52000.0		90000.0		41700.0	27600.0	50.0 K	50.0 K
01056	MANGNESE	MN,DISS	UG/L			66000.0							
01060	MOLY	MO,DISS	UG/L			146							
01062	MOLY	MO,TOT	UG/L	10	K	120		277		12	70	10 K	10 K
01067	NICKEL	NI,TOTAL	UG/L								630		

(SAMPLE CONTINUED ON NEXT PAGE)

STORET RETRIEVAL DATE 83/09/09
10671200000112O BC02BA T15NR9WS16CA
34 38 22.0 113 12 16.0 2
HILLSIDE TAILING SEEP
04025 ARIZONA YAVAPAI
COLORADO RIVER 110100
LOWER COLORADO RIVER
21ARIZ
820227 DEPTH 1
/TYPA/AMBNT/STREAM

(SAMPLE CONTINUED FROM PREVIOUS PAGE)

INITIAL DATE				82/02/10	82/04/06	82/06/17	82/08/18	82/10/15	82/12/12	83/02/16
INITIAL TIME-DEPTH-BOTTOM				1500 0001	1100 0001	1030 0001	1045 0001	1015 0001	0850	1030
01075	SILVER	AG,DISS	UG/L		50.0 K					
01077	SILVER	AG,TOT	UG/L	50.0 K	50.0 K	11.0	5.0 K	5.0 K	5.0 K	5.0 K
01090	ZINC	ZN,DISS	UG/L		380000					
01092	ZINC	ZN,TOT	UG/L	4100	120000	324000	106300	500000	80	50 K
01095	ANTIMONY	SB,DISS	UG/L		51					
01097	ANTIMONY	SB,TOT	UG/L	10	50	80	38	70	10 K	10 K
01105	ALUMINUM	AL,TOT	UG/L					255500		
01132	LITHIUM	LI,TOT	UG/L					430		
01145	SELENIUM	SE,DISS	UG/L		9					
01147	SELENIUM	SE,TOT	UG/L	5 K	6	12	61	54	5 K	5 K
01501	ALPHA	TOTAL	PC/L							2 K
03501	BETA	TOTAL	PC/L							3 K
22708	U-NAT	TOTAL	MG/L							0.001
71850	NITRATE	TOT-NO3	MG/L	0.1 K	0.8	0.1	4.4	0.4 K	0.4 K	0.4 K
71890	MERCURY	HG,DISS	UG/L		1.5 K					
71900	MERCURY	HG,TOTAL	UG/L	2.0 K	0.5 K	0.5 K	0.5 K	0.5 K	0.5 K	0.5 K
82079	TURBIDTY	LAB	NTU	1050.0	4.0	2.0	4.0	1.5	28.0	10.0
82233	SILICON	SI TOTAL	MG/L	59.37	40.80	91.60	7.60	22.00	10.00 K	9.90

10671200000118S BC029 T15NR9WS16AC
34 38 32.0 113 12 11.0 2
BOULDER CR ABOVE WILDER CR
04025 ARIZONA YAVAPAI
COLORADO RIVER 110100
LOWER COLORADO RIVER
21ARIZ
820227 DEPTH 1
/TYPA/AMBNT/STREAM

	INITIAL DATE			82/02/10	82/04/06	82/06/17	82/08/18	82/10/15	82/12/12	83/02/16
	INITIAL TIME-DEPTH-BOTTOM			1420 0001	0915 0001	0900 0001	0945	0001	0915	0900
00010	WATER	TEMP	CENT	8.0	13.0	24.0	26.0	14.5	5.0	4.7
00011	WATER	TEMP	FAHN	46.4	55.4	75.2	78.8	58.1	41.0	40.5
00020	AIR	TEMP	CENT		18.0	35.0	30.0	20.0	18.0	12.5
00061	STREAM	FLOW,	INST-CFS	1	7	0				12
00094	CNDUCTVY	FIELD,	MICROMHO	200	137	450	1080	690	78	70
00095	CNDUCTVY	AT 25C	MICROMHO	210	150	541	763	719	92	116
00116	INTNSVE	SURVEY	IDENT	820401	820401	820401	820401	820401		
00300	DO		MG/L	10.7	9.9	5.6	5.2	9.4	12.4	12.5
00301	DO	SATUR	PERCENT	89.9	93.4	65.9	63.4	92.2	96.9	97.7
00400	PH		SU	7.90	7.90	7.70	7.50	7.86	7.07	7.88
00403	LAB	PH	SU	7.9	7.9	7.9	7.5	7.7	7.1	7.3
00410	T ALK	CACO3	MG/L	66	43	189	259	233	18	27
00415	PHEN-PH-	LFIN ALK	MG/L	0	0	0	0	0	0	0
00500	RESIDUE	TOTAL	MG/L	142	105	286	515	416	83	110
00530	RESIDUE	TOT NFLT	MG/L	1	3	1	1 K	1	6	1
00615	NO2-N	TOTAL	MG/L			0.010 K				
00625	TOT KJEL	N	MG/L	0.200 K	0.200 K	0.760	0.960	0.780	1.400	0.900
00665	PHOS-TOT		MG/L P	0.050	0.050 K	0.050 K	0.520	0.050 K	0.050 K	0.050 K
00671	PHOS-DIS	ORTHO	MG/L P		0.010 K		0.150	0.010 K	0.040	0.020
00900	TOT HARD	CACO3	MG/L	60	50	126	111	112	28	40
00916	CALCIUM	CA-TOT	MG/L	18.0	14.0	40.0	26.3	30.0	8.0	11.0
00927	MGNSIUM	MG,TOT	MG/L	3.0	3.0	6.0	10.6	9.0	2.0	3.0
00929	SODIUM	NA,TOT	MG/L	16.00	8.00	59.00	114.00	124.60	10.00 K	5.90
00937	PTSSIUM	K,TOT	MG/L	1.00	1.70	3.00	4.10	2.80	1.50	1.40
00940	CHLORIDE	TOTAL	MG/L	7	4	23	51	40	1	2
00945	SULFATE	SO4-TOT	MG/L	16	11	3	12	9	14	11
00951	FLUORIDE	F,TOTAL	MG/L	2.20	1.30	3.62	6.90	7.75	0.85	1.00
01000	ARSENIC	AS,DISS	UG/L	20 K	20 K	20 K	20 K	20 K	20 K	20 K
01002	ARSENIC	AS,TOT	UG/L	20 K	20 K	20 K	20	20 K	20 K	20
01025	CADMIUM	CD,DISS	UG/L	5 K	5 K	5 K	5 K	5 K	5 K	5 K
01027	CADMIUM	CD,TOT	UG/L	5 K	5 K	5 K	8	5 K	5 K	5 K
01030	CHROMIUM	CR,DISS	UG/L	50 K	50 K	10 K	10 K	10 K	10 K	10 K
01034	CHROMIUM	CR,TOT	UG/L	50 K	50 K	10 K	10 K	10 K	10 K	10 K
01040	COPPER	CU,DISS	UG/L	50 K	50 K		10 K	10 K	10 K	10
01042	COPPER	CU,TOT	UG/L	50 K	50 K	50 K	20	16	10 K	10 K
01045	IRON	FE,TOT	UG/L	360	50 K	120	140	200	1950	1200
01046	IRON	FE,DISS	UG/L	150	50 K		100 K	100 K	200	620
01049	LEAD	PB,DISS	UG/L	20 K	20 K	20 K	20 K	20 K	20 K	20 K
01051	LEAD	PB,TOT	UG/L	20 K	20 K	20 K	20 K	20 K	20 K	20 K
01055	MANGNESE	MN	UG/L	50.0 K	50.0 K	350.0	550.0	50.0 K	50.0 K	50.0 K
01056	MANGNESE	MN,DISS	UG/L	50.0 K			430.0	50.0 K	50.0 K	50.0 K
01060	MOLY	MO,DISS	UG/L	10 K	11	35	28	12	10 K	10 K
01062	MOLY	MO,TOT	UG/L	10 K	11	13	10 K	15	10 K	10 K
01075	SILVER	AG,DISS	UG/L	50.0 K	50.0 K	5.0 K	5.0 K	50.0 K	5.0 K	5.0 K
01077	SILVER	AG,TOT	UG/L	50.0 K	50.0 K	5.0 K	5.0 K	5.0 K	5.0 K	5.0 K

(SAMPLE CONTINUED ON NEXT PAGE)

STORET RETRIEVAL DATE 83/09/09
10671200000 1105 BC029 T15NR9WS16AC
34 38 32.0 113 12 11.0 2
BOULDER CR ABOVE WILDER CR
04025 ARIZONA YAVAPAI
COLORADO RIVER 110100
LOWER COLORADO RIVER
21ARIZ
820227 DEPTH 1
/TYPA/AMBNT/STREAM

(SAMPLE CONTINUED FROM PREVIOUS PAGE)

				INITIAL DATE	82/02/10	82/04/06	82/06/17	82/08/18	82/10/15	82/12/12	83/02/16
				INITIAL TIME-DEPTH-BOTTOM	1420 0001	0915 0001	0900 0001	0945	0001	0915	0900
01090	ZINC	ZN,DISS	UG/L		50 K	50 K		50 K	50 K	50 K	50 K
01092	ZINC	ZN,TOT	UG/L		50 K	50 K	50 K	50 K	50 K	50 K	50 K
01095	ANTIMONY	SB,DISS	UG/L		10 K	10 K	10 K	10 K	10 K	10 K	10 K
01097	ANTIMONY	SE,TOT	UG/L		10 K	10 K	10 K	10 K	10 K	10 K	10 K
01105	ALUMINUM	AL,TOT	UG/L						500		
01106	ALUMINUM	AL,DISS	UG/L						500 K		
01130	LITHIUM	LI,DISS	UG/L						110		
01132	LITHIUM	LI,TOT	UG/L						110		
01145	SELENIUM	SE,DISS	UG/L		5 K	5 K	5 K	5 K	5 K	5 K	5 K
01147	SELENIUM	SE,TOT	UG/L		5 K	5 K	5 K	5 K	5 K	5 K	5 K
01501	ALPHA	TOTAL	PC/L								2 K
02921	INVALID	PAR	NUMBER			.197E+65					
03501	BETA	TOTAL	PC/L								3 K
22708	U-NAT	TOTAL	MG/L								0.002
31613	FEC COLI	M-FCAGAR	/100ML							13	3 K
31625	FEC COLI	M-FCAGAD	/100 ML		2 K	2 K	2 K	15	4		
71850	NITRATE	TOT-NO3	MG/L		0.1 K	0.0	0.1	0.2 K	0.2	0.4 K	0.4 K
71890	MERCURY	HG,DISS	UG/L		2.0 K	0.5 K	0.5 K	0.5 K	0.5 K	0.5 K	0.5 K
71900	MERCURY	HG,TOTAL	UG/L		2.0 K	0.5 K	0.5 K	0.5 K	0.5 K	0.5 K	0.5 K
82079	TURBIDTY	LAB	NTU		11.0	6.0	3.0	3.0	1.0	27.0	10.0
82233	SILICON	SI TOTAL	MG/L		11.54	8.80	8.50	13.90	15.30	13.70	12.20

106711000000005 BC031 T16NR9WS7CA
34 44 30.0 113 14 34.0 2
FRANCIS CR AT MOUTH
04025 ARIZONA YAVAPAI
COLORADO RIVER 110100
LOWER COLORADO RIVER
21ARIZ
820227 DEPTH 1
/TYPA/AMBNT/STREAM

INITIAL DATE				82/02/09	82/04/05	82/06/16	82/08/17	82/10/14	82/10/15	82/12/14	83/02/15
INITIAL TIME-DEPTH-BOTTOM				1450 0001	1315 0001	1300 0001	1300 0001	1400 0001	1400	1140	1030
00010	WATER	TEMP	CENT	10.0	17.0	25.0	28.0	17.4		7.3	8.5
00011	WATER	TEMP	FAHN	50.0	62.6	77.0	82.4	63.3		45.1	47.3
00020	AIR	TEMP	CENT		19.0	35.0	32.0	25.0		13.0	15.5
00061	STREAM	FLOW,	INST-CFS		5	1	2		2	8	
00094	CNDUCTVY	FIELD	MICROMHO	350	275	350		350		27	126
00095	CNDUCTVY	AT 25C	MICROMHO	336	270	361	383	355		270	227
00116	INTNSVE	SURVEY	IDENT	820401	820401	820401	820401	820401			
00300	DO		MG/L		9.5	10.0	9.2	12.2		13.2	10.4
00301	DO	SATUR	PERCENT		97.9	119.0	116.5	125.8		108.2	89.7
00400	PH		SU	8.50	8.50	8.30	8.70	8.75		8.17	7.90
00403	LAB	PH	SU	8.6	8.6	8.6	8.5	8.4		8.0	7.7
00410	T ALK	CACO3	MG/L	154	104	126	126	121		83	67
00415	PHEN-PH-	LFIN ALK	MG/L	8	5	4	0	2		0	0
00500	RESIDUE	TOTAL	MG/L	262	188	249	289	247		173	186
00530	RESIDUE	TOT NFLT	MG/L	5	1	3	1 K	5		3	1 K
00615	NO2-N	TOTAL	MG/L			0.010 K					
00625	TOT KJEL	N	MG/L	0.200 K	0.200 K	0.240	0.940	0.490		1.400	0.900
00665	PHOS-TOT		MG/L P	0.050	0.060	0.050 K	0.440	0.050 K		0.140	0.110
00671	PHOS-DIS	ORTHO	MG/L P			0.020	0.340	0.010		0.090	0.110
00900	TOT HARD	CACO3	MG/L	136	104	122	122	132		96	86
00916	CALCIUM	CA-TOT	MG/L	39.0	30.0	33.0	28.0	34.0		25.0	24.0
00927	MGNSIUM	MG,TOT	MG/L	9.0	7.0	10.0	12.6	11.0		8.0	6.0
00929	SODIUM	NA,TOT	MG/L	19.00	12.00	20.00	21.00	20.60		12.10	9.70
00937	PTSSIUM	K,TOT	MG/L	6.00	5.30	6.00	7.20	6.40		4.50	4.40
00940	CHLORIDE	TOTAL	MG/L	13	8	13	15	13		7	5
00945	SULFATE	SO4-TOT	MG/L	9	9	6	9	11		11	10 K
00951	FLUORIDE	F,TOTAL	MG/L	0.28	0.23	0.30 K	0.34	0.28		0.27	0.22
01000	ARSENIC	AS,DISS	UG/L		20 K	20 K	20 K	20 K		20 K	20 K
01002	ARSENIC	AS,TOT	UG/L	20 K	20 K	20 K	20 K	20 K		20 K	20 K
01025	CADMIUM	CD,DISS	UG/L		5 K	5 K	5 K	5 K		5 K	5 K
01027	CADMIUM	CD,TOT	UG/L	5 K	5 K	5 K	5 K	5 K		5 K	5 K
01030	CHROMIUM	CR,DISS	UG/L		50	10 K	10 K	10 K		10 K	10 K
01034	CHROMIUM	CR,TOT	UG/L	50 K	50 K	10 K	10 K	10 K		10 K	10 K
01040	COPPER	CU,DISS	UG/L		50 K	50 K	10 K	10 K		10 K	10 K
01042	COPPER	CU,TOT	UG/L	50 K	50 K	50 K	10 K	10 K		10 K	10 K
01045	IRON	FE,TOT	UG/L	80 K	50 K	100 K	100 K	100 K		250	500
01046	IRON	FE,DISS	UG/L		50 K	100 K	100 K	100 K		100 K	110
01049	LEAD	PB,DISS	UG/L		20 K	20 K	20 K	20 K		20 K	20 K
01051	LEAD	PB,TOT	UG/L	20 K	20 K	20 K	20 K	20 K		20 K	20 K
01055	MANGNESE	MN	UG/L	50.0 K	50.0 K	50.0 K	50.0 K	50.0 K		50.0 K	50.0 K
01056	MANGNESE	MN,DISS	UG/L		50.0 K	50.0 K	50.0 K	50.0 K		50.0 K	50.0 K
01060	MOLY	MO,DISS	UG/L		13	18	10 K	14		10 K	10 K
01062	MOLY	MO,TOT	UG/L	10 K	0 K	90 K	10 K	10 K		10 K	10 K
01075	SILVER	AG,DISS	UG/L		50.0 K	5.0 K	5.0 K	5.0 K		5.0 K	5.0 K
01077	SILVER	AG,TOT	UG/L	50.0 K	50.0 K	5.0 K	5.0 K	5.0 K		5.0 K	5.0 K

(SAMPLE CONTINUED ON NEXT PAGE)

STORET RETRIEVAL DATE 83/09/09
10671100000005 BC031 T16NR9WS7CA
34 44 30.0 113 14 34.0 2
FRANCIS CR AT MOUTH
04025 ARIZONA YAVAPAI
COLORADO RIVER 110100
LOWER COLORADO RIVER
21ARIZ
820227 DEPTH 1
/TYPA/AMBNT/STREAM

(SAMPLE CONTINUED FROM PREVIOUS PAGE)

				82/02/09	82/04/05	82/06/16	82/08/17	82/10/14	82/10/15	82/12/14	83/02/15
INITIAL DATE				1450 0001	1315 0001	1300 0001	1300 0001	1400 0001	1400	1140	1030
INITIAL TIME-DEPTH-BOTTOM											
01090	ZINC	ZN,DISS	UG/L		50 K	50	50 K	50 K		50 K	50 K
01092	ZINC	ZN,TOT	UG/L	50 K	50 K	50 K	50 K	50 K		50 K	50 K
01095	ANTIMONY	SB,DISS	UG/L			10 K	10 K	10 K		10 K	10 K
01097	ANTIMONY	SB,TOT	UG/L	10 K	0 K	10 K	10 K	10 K		10 K	10 K
01145	SELENIUM	SE,DISS	UG/L		5 K	5 K	5 K	5 K		5 K	5 K
01147	SELENIUM	SE,TOT	UG/L	5 K	5 K	5 K	5 K	5 K		5 K	5 K
31613	FEC COLI	M-FCAGAR	/100ML							5 K	3 K
31625	FEC COLI	M-FCAGAD	/100 ML		2	24	26	26			
71850	NITRATE	TOT-NO3	MG/L	2.0	0.7	0.1	0.3	0.8		1.8	1.7
71890	MERCURY	HG,DISS	UG/L		0.5 K	0.5 K	0.5 K	0.5 K		0.5 K	0.5 K
71900	MERCURY	HG,TOTAL	UG/L	2.0 K	0.5 K	0.5 K	0.5 K	0.5 K		0.5 K	0.5 K
82079	TURBIDTY	LAB	NTU	2.0	2.0	3.0	2.0	2.0		7.0	5.0
82233	SILICON	SI TOTAL	MG/L	32.43	24.60	31.10	37.40	37.40		24.90	23.40

				83/02/15
INITIAL DATE				
INITIAL TIME-DEPTH-BOTTOM				1040
00061	STREAM	FLOW,	INST-CFS	14

106711000000354 BC035 T16NR10WS1BB
34 45 42.0 113 15 59.0 2
FRANCIS CR NEAR PUMP
04025 ARIZONA YAVAPAI
COLORADO RIVER 110100
LOWER COLORADO RIVER
21ARIZ
820227 DEPTH 1
/TYPA/AMBNT/STREAM

INITIAL DATE				82/02/09	82/04/05	82/06/16	82/08/17	82/10/14	82/10/15	82/12/14	83/02/15
INITIAL TIME-DEPTH-BOTTOM				1315 0001	1130 0001	1030 0001	1045 0001	0001	1140	1015	1330
00010	WATER	TEMP	CENT	22.5	20.0	5.0	30.0	24.9		7.6	8.1
00011	WATER	TEMP	FAHN	72.5	68.0	41.0	86.0	76.8		45.7	46.6
00020	AIR	TEMP	CENT		19.0	30.0	30.0	25.0		6.0	21.0
00061	STREAM	FLOW,	INST-CFS	1	3	1	1		1	6	11
00094	CNDUCTVY	FIELD	MICROMHO	340	260	340		350		250	159
00095	CNDUCTVY	AT 25C	MICROMHO		253	376	366	345		261	191
00116	INTNSVE	SURVEY	IDENT	820401	820401	820401	820401	820401			
00300	DO		MG/L	9.7	10.1	10.5	9.6	11.8		13.4	11.3
00301	DO	SATUR	PERCENT	111.5	109.8	82.0	126.3	140.5		112.6	95.0
00400	PH		SU	8.15	8.40	8.30	8.40	8.30		7.84	8.85
00403	LAB	PH	SU	8.3	8.2	7.4	8.2	8.1		7.6	7.5
00410	T ALK	CACO3	MG/L		95	119	128	116		76	55
00415	PHEN-PH-	LPIN ALK	MG/L		0	0	0	0		0	0
00500	RESIDUE	TOTAL	MG/L	273	260	253	306	254		172	167
00530	RESIDUE	TOT NFLT	MG/L	5	1 K	1	2	2		1 K	1 K
00615	NO2-N	TOTAL	MG/L			0.010 K					
00625	TOT KJEL	N	MG/L	0.200 K	0.200 K	0.460	0.680	0.330		1.800	1.300
00665	PHOS-TOT		MG/L P	0.050	0.080	0.050 K	0.580	0.050 K		0.140	0.140
00671	PHOS-DIS	ORTHO	MG/L P			0.040	0.360	0.030		0.130	0.140
00900	TOT HARD	CACO3	MG/L	134	98	130	134	132		92	72
00916	CALCIUM	CA-TOT	MG/L	38.0	29.0	37.0	33.7	36.0		25.0	21.0
00927	MGNSIUM	MG,TOT	MG/L	9.0	6.0	9.0	12.2	10.0		7.0	7.0
00929	SODIUM	NA,TOT	MG/L	17.00	10.00	20.00	18.00	17.20		9.90	7.50
00937	PTSSIUM	K,TOT	MG/L	6.00	5.00	6.00	6.10	6.20		4.40	
00939	POTASIUM	TOT.REC.	MG/L								4
00940	CHLORIDE	TOTAL	MG/L	12	8	13	13	12		7	5
00945	SULFATE	SO4-TOT	MG/L	9	9	8	10	11		11	11
00951	FLUORIDE	F,TOTAL	MG/L	0.26	0.21	0.30	0.32	0.2[illegible]		20.00	0.20
01000	ARSENIC	AS,DISS	UG/L	20 K	20 K	20 K	20 K	20 K		20 K	20 K
01002	ARSENIC	AS,TOT	UG/L	20 K	20 K	20 K	20 K	20 K		20 K	20 K
01025	CADMIUM	CD,DISS	UG/L	5 K	5 K	5 K	5 K	5 K		5 K	5 K
01027	CADMIUM	CD,TOT	UG/L	5 K	5 K	5 K	5 K	5 K		5 K	5 K
01030	CHROMIUM	CR,DISS	UG/L	50 K	50 K	10 K	10 K	10 K		10 K	10 K
01034	CHROMIUM	CR,TOT	UG/L	50 K	50 K	10 K	10 K	10 K		10 K	10 K
01040	COPPER	CU,DISS	UG/L	50 K	50 K	50 K	22	10 K		10 K	10 K
01042	COPPER	CU,TOT	UG/L	50 K	50 K	80	10 K	10 K		10 K	10 K
01045	IRON	FE,TOT	UG/L	50 K	50 K	100 K	100 K	100 K		300	700
01046	IRON	FE,DISS	UG/L	100 K	50 K	100 K	100 K	100 K		100 K	250
01049	LEAD	PB,DISS	UG/L	20 K	20 K	20 K	20 K	20 K		20 K	20 K
01051	LEAD	PB,TOT	UG/L	20 K	20 K	20 K	20 K	20 K		20 K	20 K
01055	MANGNESE	MN	UG/L	50.0 K	50.0 K		50.0 K	50.0 K		50.0 K	50.0 K
01056	MANGNESE	MN,DISS	UG/L	50.0 K	50.0 K	50.0 K	50.0 K	50.0 K		50.0 K	50.0 K
01060	MOLY	MO,DISS	UG/L	10 K	12	10 K	0	10 K		10 K	10 K
01062	MOLY	MO,TOT	UG/L	10 K	0 K	20	13	10 K		10 K	10 K
01075	SILVER	AG,DISS	UG/L	50.0 K	50.0 K	5.0 K	5.0 K	5.0 K		5.0 K	5.0 K

(SAMPLE CONTINUED ON NEXT PAGE)

STORET RETRIEVAL DATE 83/09/09
10671100000354 BC035 T16NR10WS1BB
34 45 42.0 113 15 59.0 2
FRANCIS CR NEAR PUMP
04025 ARIZONA YAVAPAI
COLORADO RIVER 110100
LOWER COLORADO RIVER
21ARIZ
820227 DEPTH 1
/TYPA/AMBNT/STREAM

(SAMPLE CONTINUED FROM PREVIOUS PAGE)

				INITIAL DATE	82/02/09	82/04/05	82/06/16	82/08/17	82/10/14	82/10/15	82/12/14	83/02/15
				INITIAL TIME-DEPTH-BOTTOM	1315 0001	1130 0001	1030 0001	1045 0001	0001	1140	1015	1330
01077	SILVER	AG,TOT	UG/L		50.0 K	50.0 K	16.0	5.0 K	5.0 K		5.0 K	5.0 K
01090	ZINC	ZN,DISS	UG/L		50	50 K	50 K	50 K	50 K		50 K	50 K
01092	ZINC	ZN,TOT	UG/L		50 K	50 K	280	50 K	50 K		50 K	50 K
01095	ANTIMONY	SB,DISS	UG/L		10 K	10 K	10 K	0	10 K		10 K	10 K
01097	ANTIMONY	SB,TOT	UG/L		10 K	0 K	10 K	10 K	10 K		10 K	10 K
01145	SELENIUM	SE,DISS	UG/L		5 K	5 K	5 K	5 K	5 K		5 K	5 K
01147	SELENIUM	SE,TOT	UG/L		5 K	5 K	5 K	5 K	5 K		5 K	5 K
31613	FEC COLI	M-FCAGAR	/100ML								5 K	3 K
31625	FEC COLI	M-FCAGAD	/100 ML		2 K	4	4	32	29			
71850	NITRATE	TOT-NO3	MG/L		4.0	2.2	3.3	3.4	3.7		2.0	1.2
71890	MERCURY	HG,DISS	UG/L		2.0 K	0.5 K	0.5 K	0.5 K	0.5 K		0.5 K	0.5 K
71900	MERCURY	HG,TOTAL	UG/L		2.0 K	0.5 K	0.5 K	0.5 K	5.0 K		0.5 K	0.5 K
82079	TURBIDTY	LAB	NTU		2.0	2.0	2.0	2.0	1.0		8.0	7.0
82233	SILICON	SI TOTAL	MG/L		39.03	25.00	35.70	38.50	37.50		23.90	19.30

STORET RETRIEVAL DATE 83/09/09
10671100000367 EC037
34 45 47.0 113 15 59.0 2
WARM SPR ON FRANCIS CR
04025 ARIZONA YAVAPAI
COLORADO RIVER 110100
LOWER COLORADO RIVER
21ABIZ
820227 DEPTH 1
/TYPA/AMBNT/STREAM

	INITIAL DATE			82/02/09	82/04/05	82/06/16	82/08/17	82/10/14	82/12/14	83/02/15
	INITIAL TIME-DEPTH-BOTTOM			1250 0001	1115 0001	1030 0001	1045 0001	0001	1005	1315
00010	WATER	TEMP	CENT	32.0	29.5	30.0	29.0	27.5	26.8	26.8
00011	WATER	TEMP	FAHN	89.6	85.1	86.0	84.2	81.5	80.2	80.2
00020	AIR	TEMP	CENT		19.0	30.0	30.0	25.0	6.0	21.0
00061	STREAM	FLOW,	INST-CFS				0			
00094	CNDUCTVY	FIELD	MICROMHO	350	360	350		360	400	385
00095	CNDUCTVY	AT 25C	MICROMHO	337	341	380	348	354	376	350
00116	INTNSVE	SURVEY	IDENT	820401	820401	820401	820401	820401		
00300	DO		MG/L		6.8	6.6	6.7	7.4	7.4	7.0
00301	DO	SATUR	PERCENT		89.5	86.8	85.9	93.7	91.4	86.4
00400	PH		SU	7.50	7.50	7.50	7.80	7.24	7.38	7.25
00403	LAB	PH	SU	7.7	7.7	36.0	7.4	7.6	7.4	7.3
00410	T ALK	CACO3	MG/L	142	130	129	128	118	118	111
00415	PHEN-PH-	LFIN ALK	MG/L	0	0	0	0	0	0	0
00500	RESIDUE	TOTAL	MG/L	275	189	266	314	257	254	280
00530	RESIDUE	TOT NFLT	MG/L	7	1 K	1 K	1 K	1 K	1 K	1 K
00615	NO2-N	TOTAL	MG/L			0.010 K				
00625	TOT KJEL	N	MG/L	0.200 K	0.880	0.110	0.640	0.270	0.800	0.200
00665	PHOS-TOT		MG/L P	0.040	0.050 K	0.050 K	0.310	0.050	0.060	0.050 K
00671	PHOS-DIS	ORTHO	MG/L P			0.040	0.350	0.040	0.030	0.030
00900	TOT HARD	CACO3	MG/L	134	134	136	136	136	134	134
00916	CALCIUM	CA-TOT	MG/L	37.0	37.0		34.3	37.0	36.0	39.0
00927	MGNSIUM	MG,TOT	MG/L	10.0	10.0	11.0	12.1	11.0	11.0	9.0
00929	SODIUM	NA,TOT	MG/L	17.00	16.00	16.00	18.00	17.20	17.40	16.30
00937	PTSSIUM	K,TOT	MG/L	6.00	6.30	6.00	5.95	6.20	6.20	
00939	POTASIUM	TOT.REC.	MG/L							6
00940	CHLORIDE	TOTAL	MG/L	12	11	13	14	12	12	11
00945	SULFATE	SO4-TOT	MG/L	9	9	7	10	11	11	10 K
00951	FLUORIDE	F,TOTAL	MG/L	0.25	0.25	0.27	0.34	0.29	0.24	0.28
01000	ARSENIC	AS,DISS	UG/L		20 K	20 K	20 K	20 K	20 K	20 K
01002	ARSENIC	AS,TOT	UG/L	20 K	20 K	20 K	20 K	20 K	20 K	20 K
01025	CADMIUM	CD,DISS	UG/L		5 K	5 K	5 K	5 K	5 K	5 K
01027	CADMIUM	CD,TOT	UG/L	5 K	5 K	5 K	5 K	5 K	5 K	5 K
01030	CHROMIUM	CR,DISS	UG/L		50 K	10 K	10 K	10 K	10 K	10 K
01034	CHROMIUM	CR,TOT	UG/L	50 K	5 K	10 K	10 K	10 K	10 K	10 K
01040	COPPER	CU,DISS	UG/L		50 K	50 K	10 K	10 K	10 K	10 K
01042	COPPER	CU,TOT	UG/L	50 K	50 K	50 K	10 K	20	10 K	10 K
01045	IRON	FE,TOT	UG/L	50 K	50 K	100 K	100 K	100 K	100 K	100 K
01046	IRON	FE,DISS	UG/L		50 K	100 K	100 K	100 K	100 K	100 K
01049	LEAD	PB,DISS	UG/L		20 K	20 K	20 K	20 K	20 K	20 K
01051	LEAD	PB,TOT	UG/L	20 K	20 K	20 K	20 K	20 K	20 K	20 K
01055	MANGNESE	MN	UG/L	50.0 K	50.0 K	50.0 K	50.0 K	50.0 K	50.0 K	50.0 K
01056	MANGNESE	MN,DISS	UG/L		50.0 K	50.0 K	50.0 K	50.0 K	50.0 K	50.0 K
01060	MOLY	MO,DISS	UG/L		10 K	10 K	10 K	10 K	10 K	10 K
01062	MOLY	MO,TOT	UG/L	10 K	10 K	10 K	10 K	10 K	10 K	10 K
01075	SILVER	AG,DISS	UG/L		50.0 K	6.0	5.0 K	5.0 K	5.0 K	5.0 K

(SAMPLE CONTINUED ON NEXT PAGE)

STORET RETRIEVAL DATE 83/09/09
10671100000367 BC037
34 45 47.0 113 15 59.0 2
WARM SPR ON FRANCIS CR
04025 ARIZONA YAVAPAI
COLORADO RIVER 110100
LOWER COLORADO RIVER
21ARIZ
820227 DEPTH 1
/TYPA/AMBNT/STREAM

(SAMPLE CONTINUED FROM PREVIOUS PAGE)

				INITIAL DATE	82/02/09	82/04/05	82/06/16	82/08/17	82/10/14	82/12/14	83/02/15
				INITIAL TIME-DEPTH-BOTTOM	1250 0001	1115 0001	1030 0001	1045 0001	0001	1005	1315
01077	SILVER	AG,TOT	UG/L		50.0 K	50.0 K	5.0 K	5.0 K	5.0 K	5.0 K	5.0 K
01090	ZINC	ZN,DISS	UG/L			50 K	50 K	50 K	50 K	50 K	50 K
01092	ZINC	ZN,TOT	UG/L		50 K	50 K	50 K	50 K	50 K	50 K	50 K
01095	ANTIMONY	SB,DISS	UG/L			10 K	10 K	10 K	10 K	10 K	10 K
01097	ANTIMONY	SB,TOT	UG/L		10 K	10 K	10 K	10 K	10 K	10 K	10 K
01145	SELENIUM	SE,DISS	UG/L			5 K	5 K	5 K	5 K	5 K	5 K
01147	SELENIUM	SE,TOT	UG/L		5 K	5 K	5 K	5 K	5 K	5 K	5 K
31625	FEC COLI	M-FCAGAD	/100 ML						1		
71850	NITRATE	TOT-NO3	MG/L		5.0	5.7	5.4	4.9	5.0	5.0	4.7
71890	MERCURY	HG,DISS	UG/L			0.5 K	0.5 K	0.5 K	0.5 K	0.5 K	0.5 K
71900	MERCURY	HG,TOTAL	UG/L		2.0 K	0.5 K	0.5 K	0.5 K	0.5 K	0.5 K	0.5 K
82079	TURBIDTY	LAB	NTU		1.0	1.0	2.0	1.0	0.5	3.0	0.5
82233	SILICON	SI TOTAL	MG/L		36.28	36.70	35.70	38.50	37.90	40.30	36.40

STORET RETRIEVAL DATE 83/09/09
10671204000003 BC041 T15NR9W29CCA
34 36 29.0 113 13 51.0 2
COPPER CR NEAR MOUTH
04025 ARIZONA YAVAPAI
COLORADO RIVER 110100
LOWER COLORADO RIVER
21ARIZ
820227 DEPTH 1
/TYPA/AMBNT/STREAM

	INITIAL DATE			82/02/10		82/04/07		82/06/18		82/08/19		82/10/16	82/12/11	83/02/17
	INITIAL TIME-DEPTH-BOTTOM			0945 0001		0900 0001		0800 0001		1015 0001		1215 0001	0830	0845
00010	WATER	TEMP	CENT	10.0		15.0		20.0		30.0		23.8	11.3	11.0
00011	WATER	TEMP	FAHN	50.0		59.0		68.0		86.0		74.8	52.3	51.8
00020	AIR	TEMP	CENT			19.0		32.0		33.0		25.0	15.0	8.0
00094	CNDUCTVY	FIELD	MICROMHO	3000		2900		1775		3200		3000	2800	3200
00095	CNDUCTVY	AT 25C	MICROMHO	2941		2778		2174		2273		2500	3225	1818
00116	INTNSVE	SURVEY	IDENT	820401		820401		820401		820401		820401		
00300	DO		MG/L	10.0		8.3		8.7		8.1		10.1	11.2	11.4
00301	DO	SATUR	PERCENT	88.5		81.4		94.6		106.6		118.8	100.9	102.7
00400	PH		SU	8.10		7.90		7.50		8.60		7.40	7.77	8.00
00403	LAB	PH	SU	7.9		7.9		7.6		8.2		7.4	7.6	7.8
00410	T ALK	CACO3	MG/L	96		88		89		88		79	80	75
00415	PHEN-PH-	LPIN ALK	MG/L	0		0		0		0		0	0	0
00500	RESIDUE	TOTAL	MG/L	2620		2388		2359		2314		2426	2180	2491
00530	RESIDUE	TOT NFLT	MG/L	3				2		1	K	3	3	5
00625	TOT KJEL	N	MG/L	0.200	K	0.200	K	0.250		0.100	K	0.250 K	1.700	0.200
00665	PHOS-TOT		MG/L P	0.040		0.070		0.050	K	0.600		0.050 K	0.050 K	0.050 K
00671	PHOS-DIS	ORTHO	MG/L P							0.320		0.010 K	0.010	0.010
00900	TOT HARD	CACO3	MG/L	1540		1440		1480		1535		1530	1370	1530
00916	CALCIUM	CA-TOT	MG/L	424.0		380.0		372.0		347.7		388.0	360.0	404.0
00927	MGNSIUM	MG,TOT	MG/L	115.0		118.0		132.0		161.4		134.0	113.0	125.0
00929	SODIUM	NA,TOT	MG/L	125.00		119.00		105.00		109.00		108.30	93.50	107.00
00937	PTSSIUM	K,TOT	MG/L	13.00		17.20		12.00		27.80		13.40	12.20	12.50
00940	CHLORIDE	TOTAL	MG/L	59		55		53		55		54	52	54
00945	SULFATE	SO4-TOT	MG/L	145		1425		1470		1455		1703	1356	1545
00951	FLUORIDE	F,TOTAL	MG/L	3.28		2.71		2.62		3.12		3.84	2.76	2.70
01000	ARSENIC	AS,DISS	UG/L	20	K	20	K	20	K	160		20 K	20 K	20 K
01002	ARSENIC	AS,TOT	UG/L	20	K	20	K	20	K	20	K	20 K	20 K	20 K
01025	CADMIUM	CD,DISS	UG/L	5	K	5	K	5	K	5	K	5 K	5 K	7
01027	CADMIUM	CD,TOT	UG/L	5	K	5	K	5	K	5	K	14	6	6
01030	CHROMIUM	CR,DISS	UG/L	50	K	50	K	10	K	10	K	10 K	10 K	10 K
01034	CHROMIUM	CR,TOT	UG/L	50	K	50	K	10	K	10	K	10	10 K	10 K
01040	COPPER	CU,DISS	UG/L	50		50	K			22		39	600	990
01042	COPPER	CU,TOT	UG/L	60		140		50	K	44		420	410	740
01045	IRON	FE,TOT	UG/L	130		2010		910		450		1140	100 K	100 K
01046	IRON	FE,DISS	UG/L	50		50	K			100	K	100 K	100 K	100 K
01049	LEAD	PB,DISS	UG/L	20	K	20	K	20	K	20	K	20 K	20 K	20 K
01051	LEAD	PB,TOT	UG/L	20	K	20	K	20	K	20	K	20 K	20 K	20 K
01055	MANGNESE	MN	UG/L	450.0		950.0		760.0		530.0		540.0	440.0	460.0
01056	MANGNESE	MN,DISS	UG/L	440.0		880.0				550.0		550.0	430.0	460.0
01060	MOLY	MO,DISS	UG/L	20		40		10	K	21		15	20	30
01062	MOLY	MO,TOT	UG/L	20		77		36		13		10 K	17 K	10 K
01075	SILVER	AG,DISS	UG/L	50.0	K	50.0	K	5.0	K	5.0	K	5.0 K	5.0 K	5.0 K
01077	SILVER	AG,TOT	UG/L	50.0	K	50.0	K	5.0	K	5.0	K	5.0 K	5.0 K	5.0 K
01090	ZINC	ZN,DISS	UG/L	80		150				90		150	550	640
01092	ZINC	ZN,TOT	UG/L	90		50	K	200		110		170	550	650

(SAMPLE CONTINUED ON NEXT PAGE)

STORET RETRIEVAL DATE 83/09/09
10671204000003 BC041 T15NR9W29CCA
34 36 29.0 113 13 51.0 2
COPPER CR NEAR MOUTH
04025 ARIZONA YAVAPAI
COLORADO RIVER 110100
LOWER COLORADO RIVER
21ARIZ
820227 DEPTH 1
/TYPA/AMBNT/STREAM

(SAMPLE CONTINUED FROM PREVIOUS PAGE)

				82/02/10	82/04/07	82/06/18	82/08/19	82/10/16	82/12/11	83/02/17
	INITIAL DATE			0945 0001	0900 0001	0800 0001	1015 0001	1215 0001	0830	0845
	INITIAL TIME-DEPTH-BOTTOM									
01095	ANTIMONY	SB,DISS	UG/L	20	10	10	15	10 K	10 K	10 K
01097	ANTIMONY	SB,TOT	UG/L	20	10 K	16	14	10 K	10 K	10 K
01145	SELENIUM	SE,DISS	UG/L	5 K	5 K	5 K	5 K	5 K	5 K	5 K
01147	SELENIUM	SE,TOT	UG/L	5 K	5 K	5 K	5 K	5 K	5 K	5 K
71850	NITRATE	TOT-NO3	MG/L	1.9	1.6	1.9	1.0	1.5	13.3	5.4
71890	MERCURY	HG,DISS	UG/L	2.0 K	0.5 K	0.5 K	0.5 K	0.5 K	0.5 K	0.5 K
71900	MERCURY	HG,TOTAL	UG/L	2.0 K	0.5 K	0.5 K	0.5 K	0.5 K	0.5 K	0.5 K
82079	TURBIDTY	LAB	NTU	3.0	40.0	4.0	2.0	4.0	2.0	2.0
82233	SILICON	SI TOTAL	MG/L	15.39	19.20	14.80	20.20	21.10	16.80	17.50

STORET RETRIEVAL DATE 83/09/09
106712040000004 BC042
34 36 29.0 113 13 50.5 2
MONITOR WELL NR COPPER CR MOUTH
04025 ARIZONA YAVAPAI
COLORADO RIVER 110100
LOWER COLORADO RIVER
21ARIZ
830205 DEPTH 1
/TYPA/AMBNT/WELL

	INITIAL DATE			82/02/10		82/04/07		82/06/18		82/08/19		82/10/16	82/12/11	83/02/17
	INITIAL TIME-DEPTH-BOTTOM			0945 0001		0920 0001		0800 0001		1015 0001		1140 0001	0815	0830
00010	WATER	TEMP	CENT	17.0		21.0		28.0		24.0		22.0	16.8	17.0
00011	WATER	TEMP	FAHN	62.6		69.8		82.4		75.2		71.6	62.2	62.6
00020	AIR	TEMP	CENT			19.0		32.0		33.0		25.0	15.0	8.0
00094	CNDUCTVY	FIELD	MICROMHO	2500		2100		1550		3300		2450	2750	2800
00095	CNDUCTVY	AT 25C	MICROMHO	2273		2174		1887		2040		2083	2326	1695
00116	INTNSVE	SURVEY	IDENT	820401		820401		820401		820401		820401		
00300	DO		MG/L					6.9		1.6		3.1	4.9	2.6
00301	DO	SATUR	PERCENT					87.3		18.8		35.2	50.5	27.1
00400	PH		SU	7.02		7.00		7.00		6.70		6.70	6.83	7.54
00403	LAB	PH	SU	7.3		7.0		7.0		6.9		7.0	6.9	6.9
00410	T ALK	CACO3	MG/L	174		179		168		168		171	149	158
00415	PHEN-PH-	LFIN ALK	MG/L	0		0		0		0		0	0	0
00500	RESIDUE	TOTAL	MG/L	1772		1567		1706		1744		1704	1993	1861
00530	RESIDUE	TOT NFLT	MG/L	204		16		36		6		16	3	108
00625	TOT KJEL	N	MG/L	0.200	K	0.200	K	0.510		0.100	K	0.480	0.740	1.100
00665	PHOS-TOT		MG/L P	0.040		0.030	K	0.050	K	0.200		0.050	K 0.050	K 0.240
00671	PHOS-DIS	ORTHO	MG/L P							0.300				0.010
00900	TOT HARD	CACO3	MG/L	950		798		880		978		850	1110	1020
00916	CALCIUM	CA-TOT	MG/L	262.0		208.0		227.0		230.8		224.0	296.0	256.0
00927	MGNSIUM	MG,TOT	MG/L	71.0		67.0		75.0		95.9		70.0	88.0	91.0
00929	SODIUM	NA,TOT	MG/L	182.00		198.00		160.00		175.00		182.20	153.80	
00937	PTSSIUM	K,TOT	MG/L	20.00		25.50		24.00		20.30		21.00	23.00	22.00
00940	CHLORIDE	TOTAL	MG/L	59		58		55		60		61	62	62
00945	SULFATE	SO4-TOT	MG/L	1027		868		916		968		922	1143	995
00951	FLUORIDE	F,TOTAL	MG/L	3.16		3.06		3.14		3.55		3.54	2.67	2.70
01000	ARSENIC	AS,DISS	UG/L	60		20		33		130		141	59	110
01002	ARSENIC	AS,TOT	UG/L	70		30		40		450		4310	338	1000
01025	CADMIUM	CD,DISS	UG/L	5	K	5	K	5	K	5	K	5 K	5 K	5 K
01027	CADMIUM	CD,TOT	UG/L	5	K	5	K	5	K	5	K	6	5 K	5 K
01030	CHROMIUM	CR,DISS	UG/L	50	K	50	K	10	K	10	K	10 K	10 K	10 K
01034	CHROMIUM	CR,TOT	UG/L	50		50	K	10	K	10	K	10 K	10 K	10 K
01040	COPPER	CU,DISS	UG/L	50	K	50	K			10		10 K	10 K	20
01042	COPPER	CU,TOT	UG/L	60		50	K	50	K	80		4800	80	1500
01045	IRON	FE,TOT	UG/L	4500		50	K	100	K	3400		124000	11900	27400
01046	IRON	FE,DISS	UG/L	210		50	K			1120		1510	530	210
01049	LEAD	PB,DISS	UG/L	20	K	20	K	20	K	20	K	20 K	20 K	20 K
01051	LEAD	PB,TOT	UG/L	20	K	20	K	20	K	20	K	24	20 K	20 K
01055	MANGNESE	MN	UG/L	390.0		200.0		210.0		50.0		170.0	140.0	250.0
01056	MANGNESE	MN,DISS	UG/L	280.0		210.0				70.0		50.0	K 110.0	200.0
01060	MOLY	MO,DISS	UG/L	20		45		25		63		38	31	40
01062	MOLY	MO,TOT	UG/L	20		55		68		67		23	45	50
01075	SILVER	AG,DISS	UG/L	50.0	K	50.0	K	5.0		5.0	K	5.0 K	5.0 K	5.0 K
01077	SILVER	AG,TOT	UG/L	50.0	K	50.0	K	5.0	K	5.0	K	5.0 K	5.0 K	5.0 K
01090	ZINC	ZN,DISS	UG/L	50	K	50				190		270	340	17300
01092	ZINC	ZN,TOT	UG/L	80		50	K	50	K	200	K	1560	580	8400

(SAMPLE CONTINUED ON NEXT PAGE)

STORET RETRIEVAL DATE 83/09/09
10671204000004 BC042
34 36 29.0 113 13 50.5 2
MONITOR WELL NR COPPER CR MOUTH
04025 ARIZONA YAVAPAI
COLORADO RIVER 110100
LOWER COLORADO RIVER
21ABIZ
830205 DEPTH 1
/TYPA/AMBNT/WELL

(SAMPLE CONTINUED FROM PREVIOUS PAGE)

				INITIAL DATE	82/02/10	82/04/07	82/06/18	82/08/19	82/10/16	82/12/11	83/02/17
				INITIAL TIME-DEPTH-BOTTOM	0945 0001	0920 0001	0800 0001	1015 0001	1140 0001	0815	0830
01095	ANTIMONY	SB,DISS	UG/L		30	13	12	11	10 K	10 K	10 K
01097	ANTIMONY	SB,TOT	UG/L		30	16	18	14	20	10 K	10 K
01145	SELENIUM	SE,DISS	UG/L		5 K	5 K	6	5 K	5 K	5 K	5 K
01147	SELENIUM	SE,TOT	UG/L		5 K	5 K	5 K	5 K	5 K	5 K	5 K
71850	NITRATE	TOT-NO3	MG/L		2.9	4.9	1.2	5.8	3.8	5.5	0.4 K
71890	MERCURY	HG,DISS	UG/L		2.0 K	0.5 K	0.5 K	0.5 K	0.5 K	0.5 K	0.5 K
71900	MERCURY	HG,TOTAL	UG/L		2.0 K	0.5 K	0.5 K	0.5 K	0.5 K	0.5 K	0.5 K
82079	TURBIDTY	LAB	NTU		37.0	21.0	24.0	8.0	40.0	5.0	85.0
82233	SILICON	SI TOTAL	MG/L		24.19	16.70	13.70	17.50	20.10	16.20	13.40

10671204000012 9 BC045 T14NR9WS4AC DDH2281
34 35 58.0 113 13 25.0 2
THERMAL SPR IN EAST PIT
04025 ARIZONA YAVAPAI
COLORADO RIVER 110100
LOWER COLORADO RIVER
21ARIZ
820227 DEPTH 1
/TYPA/AMBNT/STREAM

	INITIAL DATE			82/02/11	
	INITIAL TIME-DEPTH-BOTTOM			0845 0011	
00010	WATER	TEMP	CENT	34.0	
00011	WATER	TEMP	FAHN	93.2	
00094	CNDUCTVY	FIELD	MICROMHO	490	
00116	INTNSVE	SURVEY	IDENT	820401	
00400	PH		SU	7.40	
00900	TOT HARD	CACO3	MG/L	112	
00916	CALCIUM	CA-TOT	MG/L	39.0	
00927	MGNSIUM	MG,TOT	MG/L	3.0	
00929	SODIUM	NA,TOT	MG/L	59.00	
00937	PTSSIUM	K,TOT	MG/L	3.00	
00940	CHLORIDE	TOTAL	MG/L	13	
00951	FLUORIDE	F,TOTAL	MG/L	2.16	
01002	ARSENIC	AS,TOT	UG/L	20	K
01027	CADMIUM	CD,TOT	UG/L	5	K
01034	CHROMIUM	CR,TOT	UG/L	50	K
01042	COPPER	CU,TOT	UG/L	50	K
01045	IRON	FE,TOT	UG/L	90	
01051	LEAD	PB,TOT	UG/L	20	K
01055	MANGNESE	MN	UG/L	50.0	K
01062	MOLY	MO,TOT	UG/L	30	
01077	SILVER	AG,TOT	UG/L	50.0	K
01092	ZINC	ZN,TOT	UG/L	50	K
01097	ANTIMONY	SB,TOT	UG/L	10	
01147	SELENIUM	SE,TOT	UG/L	5	K
71900	MERCURY	HG,TOTAL	UG/L	2.0	K

STORET RETRIEVAL DATE 83/09/09
10671203000000 1 BC050 T15NR9WS29AA
34 37 08.0 113 13 00.0 2
BUTTE CR AT MOUTH
04025 ARIZONA YAVAPAI
COLORADO RIVER 110100
LOWER COLORADO RIVER
21ARIZ
820227 DEPTH 1
/TYPA/AMBNT/STREAM

INITIAL DATE				82/02/10	82/04/06	82/08/18	82/08/19	82/10/16	82/12/12	82/12/12	82/12/12
INITIAL TIME-DEPTH-BOTTOM				1200 0001	1525 0001	0850	0850 0001	0920 0001	0900	1345	
00010	WATER	TEMP	CENT	9.8	19.0		23.0	13.0			
00011	WATER	TEMP	FAHN	49.6	66.2		73.4	55.4			
00020	AIR	TEMP	CENT		20.0		24.0	20.0			
00061	STREAM	FLOW,	INST-CFS		0	0		0		1	
00094	CNDUCTVY	FIELD	MICROMHO	510	490		930	490			
00095	CNDUCTVY	AT 25C	MICROMHO	637	521		667	694			340
00116	INTNSVE	SURVEY	IDENT	820401	820401		820401	820401			
00300	DO		MG/L	9.9	8.0		8.3	12.2			
00301	DO	SATUR	PERCENT	87.6	85.1		95.4	115.1			
00400	PH		SU	8.40	8.10		8.40	8.27			
00403	LAB	PH	SU	8.4	8.3		8.3	8.4			7.9
00410	T ALK	CACO3	MG/L	250	166		215	210			86
00415	PHEN-PH-	LFIN ALK	MG/L	4	0		0	0			0
00500	RESIDUE	TOTAL	MG/L	395	318		401	401			198
00530	RESIDUE	TOT NFLT	MG/L	1 K	30		3	3			5
00625	TOT KJEL	N	MG/L	0.200 K	0.640		0.100 K	0.400			1.500
00665	PHOS-TOT		MG/L P	0.050	0.130		0.290	0.050 K			0.070
00671	PHOS-DIS	ORTHO	MG/L P		0.010 K			0.010 K			
00900	TOT HARD	CACO3	MG/L	210	166		200	180			104
00916	CALCIUM	CA-TOT	MG/L	66.0	50.0		41.4	46.0			30.0
00927	MGNSIUM	MG,TOT	MG/L	11.0	10.0		23.5	15.0			7.0
00929	SODIUM	NA,TOT	MG/L	54.00	38.00		80.00	78.80			24.40
00937	PTSSIUM	K,TOT	MG/L	4.00	5.40		5.10	5.50			2.20
00940	CHLORIDE	TOTAL	MG/L	17	14		25	21			8
00945	SULFATE	SO4-TOT	MG/L	41	34		65	67			26
00951	FLUORIDE	F,TOTAL	MG/L	2.70	2.46		4.12	4.00			2.04
01000	ARSENIC	AS,DISS	UG/L		20 K			24			
01002	ARSENIC	AS,TOT	UG/L	20 K	20 K		38	24			20 K
01025	CADMIUM	CD,DISS	UG/L		5 K			5 K			
01027	CADMIUM	CD,TOT	UG/L	5 K	5 K		5 K	5 K			5 K
01030	CHROMIUM	CR,DISS	UG/L		50 K			10 K			
01034	CHROMIUM	CR,TOT	UG/L	50 K	50 K		10 K	10 K			10 K
01040	COPPER	CU,DISS	UG/L		50 K			10 K			
01042	COPPER	CU,TOT	UG/L	50 K	50 K		10 K	10			10
01045	IRON	FE,TOT	UG/L	140	240		100 K	100 K			180
01046	IRON	FE,DISS	UG/L		50 K			100 K			
01049	LEAD	PB,DISS	UG/L		20 K			20 K			
01051	LEAD	PB,TOT	UG/L	20 K	20 K		20 K	20 K			20 K
01055	MANGNESE	MN	UG/L	550.0	180.0		50.0 K	50.0 K			220.0
01056	MANGNESE	MN,DISS	UG/L		150.0			50.0 K			
01060	MOLY	MO,DISS	UG/L		20			30			
01062	MOLY	MO,TOT	UG/L	30	20		38	30			13
01075	SILVER	AG,DISS	UG/L		50.0 K			5.0 K			
01077	SILVER	AG,TOT	UG/L	50.0 K	50.0 K		5.0 K	5.0 K			5.0 K
01090	ZINC	ZN,DISS	UG/L		50 K			50 K			

(SAMPLE CONTINUED ON NEXT PAGE)

10671203000001 BC050 T15NR9WS29AA
34 37 08.0 113 13 00.0 2
BUTTE CR AT MOUTH
04025 ARIZONA YAVAPAI
COLORADO RIVER 110100
LOWER COLORADO RIVER
21ARIZ
820227 DEPTH 1
/TYPA/AMBNT/STREAM

(SAMPLE CONTINUED FROM PREVIOUS PAGE)

INITIAL DATE				82/02/10	82/04/06	82/08/18	82/08/19	82/10/16	82/12/12	82/12/12	82/12/12
INITIAL TIME-DEPTH-BOTTOM				1200 0001	1525 0001	0850	0850 0001	0920 0001	0900	1345	
01092	ZINC	ZN,TOT	UG/L	50 K	50 K		50 K	50 K			50 K
01095	ANTIMONY	SB,DISS	UG/L		10 K			10 K			
01097	ANTIMONY	SB,TOT	UG/L	10	10 K		12	10 K			10 K
01145	SELENIUM	SE,DISS	UG/L		5 K			5 K			
01147	SELENIUM	SE,TOT	UG/L	5 K	5 K		5 K	5 K			5 K
31613	FEC COLI	M-FCAGAR	/100ML						17		5
31625	FEC COLI	M-FCAGAD	/100 ML		2 K			10			
71850	NITRATE	TOT-NO3	MG/L	0.1 K	0.5		0.2 K	0.4 K			2.4
71890	MERCURY	HG,DISS	UG/L		0.5 K			0.5 K			
71900	MERCURY	HG,TOTAL	UG/L	2.0 K	0.5 K		0.5 K	0.5 K			0.5 K
82079	TURBIDTY	LAB	NTU	2.0	13.0		2.0	1.0			5.0
82233	SILICON	SI TOTAL	MG/L	17.40	23.80		19.60	16.30			1.70
INITIAL DATE				83/02/16							
INITIAL TIME-DEPTH-BOTTOM				1510							
00010	WATER	TEMP	CENT	10.3							
00011	WATER	TEMP	FAHN	50.5							
00020	AIR	TEMP	CENT	18.0							
00061	STREAM	FLOW,	INST-CFS	0							
00094	CNDUCTVY	FIELD	MICROMHO	260							
00095	CNDUCTVY	AT 25C	MICROMHO	370							
00300	DO		MG/L	11.8							
00301	DO	SATUR	PERCENT	104.4							
00400	PH		SU	8.43							
00403	LAB	PH	SU	8.0							
00410	T ALK	CACO3	MG/L	111							
00415	PHEN-PH-	LFIN ALK	MG/L	0							
00500	RESIDUE	TOTAL	MG/L	272							
00530	RESIDUE	TOT NFLT	MG/L	12							
00625	TOT KJEL	N	MG/L	2.400							
00665	PHOS-TOT		MG/L P	50.000 K							
00671	PHOS-DIS	ORTHO	MG/L P	0.020							
00900	TOT HARD	CACO3	MG/L	138							
00916	CALCIUM	CA-TOT	MG/L	40.8							
00927	MGNSIUM	MG,TOT	MG/L	9.0							
00929	SODIUM	NA,TOT	MG/L	32.30							
00937	PTSSIUM	K,TOT	MG/L	2.60							
00940	CHLORIDE	TOTAL	MG/L	12							
00945	SULFATE	SO4-TOT	MG/L	35							
00951	FLUORIDE	F,TOTAL	MG/L	2.60							
01000	ARSENIC	AS,DISS	UG/L	20 K							
01002	ARSENIC	AS,TOT	UG/L	20 K							
01025	CADMIUM	CD,DISS	UG/L	5 K							
01027	CADMIUM	CD,TOT	UG/L	5 K							
01030	CHROMIUM	CR,DISS	UG/L	10 K							

(SAMPLE CONTINUED ON NEXT PAGE)

106712030000001 BC050 T15NR9WS29AA
34 37 08.0 113 13 00.0 2
BUTTE CR AT MOUTH
04025 ARIZONA YAVAPAI
COLORADO RIVER 110100
LOWER COLORADO RIVER
21ARIZ
820227 DEPTH 1
/TYPA/AMBNT/STREAM

(SAMPLE CONTINUED FROM PREVIOUS PAGE)

	INITIAL DATE			83/02/16	
	INITIAL TIME-DEPTH-BOTTOM			1510	
01034	CHROMIUM	CR,TOT	UG/L	10	K
01040	COPPER	CU,DISS	UG/L	110	
01042	COPPER	CU,TOT	UG/L	20	
01045	IRON	FE,TOT	UG/L	500	
01046	IRON	FE,DISS	UG/L	100	K
01049	LEAD	PB,DISS	UG/L	20	K
01051	LEAD	PB,TOT	UG/L	20	K
01055	MANGNESE	MN	UG/L	380.0	
01056	MANGNESE	MN,DISS	UG/L	310.0	
01060	MOLY	MO,DISS	UG/L	10	
01062	MOLY	MO,TOT	UG/L	20	
01075	SILVER	AG,DISS	UG/L	5.0	K
01077	SILVER	AG,TOT	UG/L	5.0	K
01090	ZINC	ZN,DISS	UG/L	50	K
01092	ZINC	ZN,TOT	UG/L	50	K
01095	ANTIMONY	SB,DISS	UG/L	10	K
01097	ANTIMONY	SB,TOT	UG/L	10	K
01145	SELENIUM	SE,DISS	UG/L	5	K
01147	SELENIUM	SE,TOT	UG/L	5	K
31613	FEC COLI	M-FCAGAR	/100ML	3	
71850	NITRATE	TOT-NO3	MG/L	0.4	K
71890	MERCURY	HG,DISS	UG/L	0.5	K
71900	MERCURY	HG,TOTAL	UG/L	0.5	K
82079	TURBIDTY	LAB	NTU	8.5	
82233	SILICON	SI TOTAL	MG/L	14.60	

10671202000000 1 BC060 T15NR9WS16DB
34 38 30.0 113 12 15.0 2
WILDER CR AT MOUTH
04025 ARIZONA YAVAPAI
COLORADO RIVER 110100
LOWER COLORADO RIVER
21ARIZ
820227 DEPTH 1
/TYPA/AMBNT/STREAM

	INITIAL DATE			82/02/10		82/04/06	82/06/17	82/08/18	83/02/16	
	INITIAL TIME-DEPTH-BOTTOM			1400 0001		0930 0001	0900 0001	0945 0001	0840	
00010	WATER	TEMP	CENT	8.2		13.5	24.0	25.0	6.0	
00011	WATER	TEMP	FAHN	46.8		56.3	75.2	77.0	42.8	
00020	AIR	TEMP	CENT			18.0	35.0	30.0	10.5	
00061	STREAM	FLOW,	INST-CFS	1		1	0		2	
00094	CNDUCTVY	FIELD	MICROMHO	500		400	530	830	245	
00095	CNDUCTVY	AT 25C	MICROMHO	503		395	592	606	343	
00116	INTNSVE	SURVEY	IDENT	820401		820401	820401	820401		
00300	DO		MG/L	10.7		10.7	5.9	5.7	11.9	
00301	DO	SATUR	PERCENT	89.9		102.9	69.4	67.9	95.2	
00400	PH		SU	8.30		8.50	8.10	8.30	8.49	
00403	LAB	PH	SU	8.4		8.5	8.3	8.2	7.9	
00410	T ALK	CACO3	MG/L	282		161	211	205	119	
00415	PHEN-PH-	LFIN ALK	MG/L	4		4	0	0	0	
00500	RESIDUE	TOTAL	MG/L	300		246	328	430	228	
00530	RESIDUE	TOT NFLT	MG/L	1	K	2	1	1	1	K
00615	NO2-N	TOTAL	MG/L				0.010	K		
00625	TOT KJEL	N	MG/L	0.200	K	0.200 K	0.560	1.600	0.800	
00665	PHOS-TOT		MG/L P	0.040		0.030 K	0.050 K	0.520	0.060	
00671	PHOS-DIS	ORTHO	MG/L P			0.010 K	0.010 K	0.230	0.030	
00900	TOT HARD	CACO3	MG/L	150		128	150	141	120	
00916	CALCIUM	CA-TOT	MG/L	50.0		38.0	44.0	25.3	34.0	
00927	MGNSIUM	MG,TOT	MG/L	6.0		8.0	10.0	18.8	8.0	
00929	SODIUM	NA,TOT	MG/L	50.00		32.00	63.00	76.00	24.90	
00937	PTSSIUM	K,TOT	MG/L	4.00		5.10	7.00	8.90	4.00	
00940	CHLORIDE	TOTAL	MG/L	17		10	26	44	7	
00945	SULFATE	SO4-TOT	MG/L	17		9	5	8	10	K
00951	FLUORIDE	F,TOTAL	MG/L	1.40		0.92	1.17	1.42	0.74	
01000	ARSENIC	AS,DISS	UG/L	20	K	20 K	20 K	33	20	K
01002	ARSENIC	AS,TOT	UG/L	20	K	20 K	20 K	20 K	20	K
01025	CADMIUM	CD,DISS	UG/L	5	K	5 K	5 K	5 K	5	K
01027	CADMIUM	CD,TOT	UG/L	5	K	5 K	5 K	5 K	5	K
01030	CHROMIUM	CR,DISS	UG/L	50	K	50 K	10 K	10 K	10	K
01034	CHROMIUM	CR,TOT	UG/L	50	K	50 K	10 K	10 K	10	K
01040	COPPER	CU,DISS	UG/L	50	K	50 K		10 K	40	
01042	COPPER	CU,TOT	UG/L	50	K	50 K	50 K		10	K
01045	IRON	FE,TOT	UG/L	50	K	50 K	100 K	30 K	100	
01046	IRON	FE,DISS	UG/L	50	K	50 K		100 K	10	K
01049	LEAD	PB,DISS	UG/L	20	K	20 K	20 K	20 K	20	K
01051	LEAD	PB,TOT	UG/L	20	K	20 K	20 K	20 K	20	K
01055	MANGNESE	MN	UG/L	50.0	K	50.0 K	50.0 K	50.0 K	50.0	K
01056	MANGNESE	MN,DISS	UG/L	0.6		50.0 K		50.0 K	50.0	K
01060	MOLY	MO,DISS	UG/L	0		13	10 K	23	10	K
01062	MOLY	MO,TOT	UG/L	10		10 K	10 K	16	20	
01075	SILVER	AG,DISS	UG/L	50.0	K	50.0 K	5.0 K	5.0 K	5.0	K
01077	SILVER	AG,TOT	UG/L	50.0	K	50.0 K	5.0 K	5.0 K	5.0	K

(SAMPLE CONTINUED ON NEXT PAGE)

STORET RETRIEVAL DATE 83/09/09
10671202000000 1 BC060 T15NR9WS16DB
34 38 30.0 113 12 15.0 2
WILDER CR AT MOUTH
04025 ARIZONA YAVAPAI
COLORADO RIVER 110100
LOWER COLORADO RIVER
21ARIZ
820227 DEPTH 1
/TYPA/AMBNT/STREAM

(SAMPLE CONTINUED FROM PREVIOUS PAGE)

				INITIAL DATE	82/02/10	82/04/06	82/06/17	82/08/18	83/02/16
				INITIAL TIME-DEPTH-BOTTOM	1400 0001	0930 0001	0900 0001	0945 0001	0840
01090	ZINC	ZN,DISS	UG/L		50 K	50 K		50 K	50 K
01092	ZINC	ZN,TOT	UG/L		50 K	50 K	50 K	50 K	50 K
01095	ANTIMONY	SB,DISS	UG/L		10 K	10 K	10 K	10 K	10 K
01097	ANTIMONY	SB,TOT	UG/L		10 K	10 K	10 K	10 K	10 K
01145	SELENIUM	SE,DISS	UG/L		5 K	50 K	5 K	5 K	5 K
01147	SELENIUM	SE,TOT	UG/L		5 K	5 K	5 K	5 K	5 K
31613	FEC COLI	M-FCAGAR	/100ML						3 K
31625	FEC COLI	M-FCAGAD	/100 ML		2 K	2 K	2	4	
71850	NITRATE	TOT-NO3	MG/L		0.1 K	0.0	0.1	0.6	0.4 K
71890	MERCURY	HG,DISS	UG/L		2.0 K	0.5 K	0.5 K	0.5 K	0.5 K
71900	MERCURY	HG,TOTAL	UG/L		20.0 K	0.5 K	0.5 K	0.5 K	0.5 K
82079	TURBIDTY	LAB	NTU		1.0	2.0	2.0	2.0	1.8
82233	SILICON	SI TOTAL	MG/L		17.59	15.90	21.20	26.40	15.80

STORET RETRIEVAL DATE 83/09/09
10671202000020 BC061
34 38 33.0 113 12 20.0 2
WILDER CR 300 YDS ABOVE MOUTH
04025 ARIZONA YAVAPAI
COLORADO RIVER 110100
LOWER COLORADO RIVER
21ARIZ
830205 DEPTH 1
/TYPA/AMBNT/STREAM

	INITIAL DATE			82/10/15	
	INITIAL TIME-DEPTH-BOTTOM			0915 0001	
00010	WATER	TEMP	CENT	14.5	
00011	WATER	TEMP	FAHN	58.1	
00020	AIR	TEMP	CENT	20.0	
00094	CNDUCTVY	FIELD	MICROMHO	700	
00095	CNDUCTVY	AT 25C	MICROMHO	694	
00116	INTNSVE	SURVEY	IDENT	820401	
00300	DO		MG/L	10.9	
00301	DO	SATUR	PERCENT	106.9	
00400	PH		SU	8.80	
00403	LAB	PH	SU	8.7	
00410	T ALK	CACO3	MG/L	200	
00415	PHEN-PH-	LFIN ALK	MG/L	12	
00500	RESIDUE	TOTAL	MG/L	406	
00530	RESIDUE	TOT NFLT	MG/L	3	
00625	TOT KJEL	N	MG/L	1.150	
00665	PHOS-TOT		MG/L P	0.050	K
00671	PHOS-DIS	ORTHO	MG/L P	0.010	K
00900	TOT HARD	CACO3	MG/L	126	
00916	CALCIUM	CA-TOT	MG/L	32.0	
00927	MGNSIUM	MG,TOT	MG/L	11.0	
00929	SODIUM	NA,TOT	MG/L	104.00	
00937	PTSSIUM	K,TOT	MG/L	9.80	
00940	CHLORIDE	TOTAL	MG/L	64	
00945	SULFATE	SO4-TOT	MG/L	9	
00951	FLUORIDE	F,TOTAL	MG/L	1.65	
01000	ARSENIC	AS,DISS	UG/L	20	K
01002	ARSENIC	AS,TOT	UG/L	20	K
01025	CADMIUM	CD,DISS	UG/L	5	K
01027	CADMIUM	CD,TOT	UG/L	5	K
01030	CHROMIUM	CR,DISS	UG/L	10	K
01034	CHROMIUM	CR,TOT	UG/L	10	K
01040	COPPER	CU,DISS	UG/L	10	K
01042	COPPER	CU,TOT	UG/L	30	
01045	IRON	FE,TOT	UG/L	100	K
01046	IRON	FE,DISS	UG/L	100	K
01049	LEAD	PB,DISS	UG/L	20	K
01051	LEAD	PB,TOT	UG/L	20	K
01055	MANGNESE	MN	UG/L	50.0	K
01056	MANGNESE	MN,DISS	UG/L	50.0	K
01060	MOLY	MO,DISS	UG/L	16	
01062	MOLY	MO,TOT	UG/L	10	
01075	SILVER	AG,DISS	UG/L	5.0	K
01077	SILVER	AG,TOT	UG/L	5.0	K
01090	ZINC	ZN,DISS	UG/L	50	K
01092	ZINC	ZN,TOT	UG/L	50	K

(SAMPLE CONTINUED ON NEXT PAGE)

STORET RETRIEVAL DATE 83/09/09
106712020000020 BC061
34 38 33.0 113 12 20.0 2
WILDER CR 300 YDS ABOVE MOUTH
04025 ARIZONA YAVAPAI
COLORADO RIVER 110100
LOWER COLORADO RIVER
21ARIZ
830205 DEPTH 1
/TYPA/AMBNT/STREAM

(SAMPLE CONTINUED FROM PREVIOUS PAGE)

	INITIAL DATE			82/10/15
	INITIAL TIME-DEPTH-BOTTOM			0915 0001
01095	ANTIMONY	SB,DISS	UG/L	10 K
01097	ANTIMONY	SB,TOT	UG/L	10 K
01145	SELENIUM	SE,DISS	UG/L	5 K
01147	SELENIUM	SE,TOT	UG/L	5 K
31625	FEC COLI	M-FCAGAD	/100 ML	2 K
71850	NITRATE	TOT-NO3	MG/L	0.3
71890	MERCURY	HG,DISS	UG/L	0.5 K
71900	MERCURY	HG,TOTAL	UG/L	0.5 K
82079	TURBIDTY	LAB	NTU	1.0
82233	SILICON	SI TOTAL	MG/L	24.40

STORET RETRIEVAL DATE 83/09/09
10671200000 1052 BC100
34 38 22.1 113 12 37.0 2
SEEP ON HILLSIDE TAILINGS ROAD
04025 ARIZONA YAVAPAI
COLORADO RIVER 110100
LOWER COLORADO RIVER
21ARIZ
830409 DEPTH 1
/TYPA/AMBNT/STREAM

	INITIAL DATE			82/04/06	83/02/16	
	INITIAL TIME-DEPTH-BOTTOM			0830 0001	1130	
00095	CNDUCTVY	AT 25C	MICROMHO	50000		
00116	INTNSVE	SURVEY	IDENT	820401		
00403	LAB	PH	SU	2.5		
00410	T ALK	CACO3	MG/L	0		
00415	PHEN-PH-	LFIN ALK	MG/L	0		
00500	RESIDUE	TOTAL	MG/L	706		
00530	RESIDUE	TOT NFLT	MG/L	302		
00900	TOT HARD	CACO3	MG/L	44138		
00916	CALCIUM	CA-TOT	MG/L	571.5		
00927	MGNSIUM	MG,TOT	MG/L	7729.0		
00929	SODIUM	NA,TOT	MG/L	4.00		
00937	PTSSIUM	K,TOT	MG/L	1.00	K	
00940	CHLORIDE	TOTAL	MG/L	30		
00945	SULFATE	SO4-TOT	MG/L	102606		
00951	FLUORIDE	F,TOTAL	MG/L	0.25		
01002	ARSENIC	AS,TOT	UG/L	163		
01027	CADMIUM	CD,TOT	UG/L	100		
01034	CHROMIUM	CR,TOT	UG/L	990		
01042	COPPER	CU,TOT	UG/L	750000		
01045	IRON	FE,TOT	UG/L	.380E+07		
01051	LEAD	PB,TOT	UG/L	270		
01055	MANGNESE	MN	UG/L	.116E+07		
01062	MOLY	MO,TOT	UG/L	4		
01077	SILVER	AG,TOT	UG/L	50.0	K	
01092	ZINC	ZN,TOT	UG/L	.129E+07		
01097	ANTIMONY	SB,TOT	UG/L	100		
01147	SELENIUM	SE,TOT	UG/L	500		
01501	ALPHA	TOTAL	PC/L			3018
01502	ALPHA-T	ERROR	PC/L			533
03501	BETA	TOTAL	PC/L			4366
03502	BETA-T	ERROR	PC/L			174
09501	RA-226	TOTAL	PC/L			893.0
09502	RA-226	ERROR	PC/L			38.0
11501	RA-228	TOTAL	PC/L			1550.0
11502	RA-228	ERROR	PC/L			68.0
22708	U-NAT	TOTAL	MG/L			3980.00
71900	MERCURY	HG,TOTAL	UG/L	8.0		
82233	SILICON	SI TOTAL	MG/L	35.40		

APPENDIX B

Quality Control Data,

Burro Creek Water

Quality Study

(This section includes:

ADHS quality control data

sheets, each of which

follows the

corresponding field data

sheet; and,

quality control data provided

by Dr. Donald Runnells by

permission of Cyprus-Bagdad

Copper Corp.)

CIMEN SUBMITTING
D REPORTING FORM | 1 | 7 | (25 26)

State of Arizona
Department of Health Services
State Laboratory

Date Rec'd. JUN 21 11 25 AM '82 (3 8)

J. M. COUNTS, Dr.P.H., Chief

ATER QUALITY ANALYSIS - Chemical

SPECIMEN UNSATISFACTORY
Reason: _____ CODE

CIMEN NUMBER 2403 | SYSTEM NUMBER

E OF CLIENT F K Swanson | IDENTIFICATION NUMBER (17 24)

RESS BWQC

Phx | STATE | ZIP CODE | COUNTY | CODE (15 16)

SOURCE TYPE (check one)
☐ Well ☐ Surface ☐ Sewage ☐ Industrial ☐ Seepage

SOURCE DATA (check each applicable box)
☐ Public System ☐ Individual System
☐ Treated ☐ Untreated
☐ Routine Sample ☐ Re-Sample ☐ Special
☐ Grab Sample ☐ Composite Sample
☐ New Source ☐ Existing Source

AB USE ONLY
ab Performing Test
hoenix - 1
agstaff - 2
ucson - 3 (27)
DO NOT CHARGE (28)

MAILING ADDRESS OF REPORT
ADDRESS
CITY | STATE | ZIP CODE

FIELD DATA -
Conductivity _____ Mhos D.O. _____ pH _____
Air Temp. _____ °C. Water Temp. _____ °C.
Well Depth _____ Static Water Level _____
Gage Height _____ Discharge _____ CFS
Depth to Surface _____ _____ GPM

SAMPLE APPEARANCE -
☐ Clear ☐ Turbid ☐ Silty ☐ Floating ☐ Other

WEATHER -
☐ Clear ☑ Cloudy ☐ Rain ☐ Snow ☐ Other

SAMPLER'S COMMENTS: _____

TEM OR SOURCE NAME Burro Cr Study | CITY | WELL NUMBER

ATION OF SAMPLING POINT | WELL NAME

NTY | TOWNSHIP | RANGE | SECTION | COLLECTED BY

TUDE | LONGITUDE | STATION NUMBER | DATE COLLECTED 6-82 | HOUR

RET NUMBER | CONTROL NUMBER QC-1 | PRESERVATIVE ADDED? ☑ YES ☐ NO

	D	T	ME/L	Mg/L
☑ ROUTINE WATER CHEMISTRY				
☑ Specific Resistance (OHMS) 1700				
☑ pH 8.4				
3 ☑ CATIONS				
☑ Calcium				41
☑ Magnesium				18
☑ Sodium				54
☑ Iron (0.3)				<0.10
☑ Copper (1.0)				<0.05
☑ Manganese (0.05)				<0.05
☑ Zinc (5.0)				<0.05
Σ(+) = 6.1041				
1 ☑ ANIONS				
☑ Alk P (CaCO3)				1.8
☑ Alk MP (CaCO3)				132.8
☑ Chloride (250)				46
☑ Nitrate (45) NO3				3.46
☑ Sulfate (250)				69.44
☑ Total PO4 -P				<0.05
☑ Fluorides				1.11
☐ Nitrite				
D - Dissolved T - Total Σ(-) = 5.5132				

	Mg/L
29 ☐ Solids	
30 ☑ Residue	380
31 ☐ T.D.S. Calc.	
32 ☑ Hardness (CaCO3)	176
33 ☑ Total S.S.	<1
34 ☐ V.S.S.	
35 ☐ Surfactants	
36 ☐ B.O.D.	
37 ☐ C.O.D.	
39 ☑ Kjeldahl Nitrogen Total	<0.1
40 ☑ Others K	9
Mo	<0.010
Sb	0.011
mass balance	

☐ Acceptable for Public Usage
☐ Provisionally Accepted for Public Usage*
☐ Rejected for Public Usage*
☐ Based on Parameters Run
*See attached for interpretation
Evaluated by _____
Bureau of Water Quality Control
Date _____

	D	T	Mg/L
41 ☑ TRACE METALS (Mg/l)			
42 ☑ Arsenic (.01) (.05)			<0.02
43 ☑ Silver (.05)			<0.025
44 ☑ Chromium (0.05)			<0.010
45 ☑ Cadmium (0.01)			<0.005
46 ☑ Lead (0.05)			<0.02
47 ☑ Selenium (0.01)			<0.005
48 ☑ Mercury (.005)			<0.0005
50 ☐ SPECIAL			
49 ☐ [redacted] Si			12.0
51 ☐ Radiological			
52 ☐ Petroleum Res.			
53 ☐ C.C.E. (0.2)			
54 ☐ Phenols (0.001)			
55 ☐ Pesticides			
56 ☑ PHYSICAL			
☐ Color			
☐ Taste			
☐ Odor			
☑ Turbidity			1

COMMENTS _____

Analyst Lee Ann Pasqualone Date Reported 7/19/82

LABORATORY COPY

AS/DCS/Epidemiology and Laboratory Services-17 (5-76)

SPECIMEN SUBMITTING AND REPORTING FORM 17 (25 26)

State of Arizona
Department of Health Services
State Laboratory

Date rec'd. 6-22-82 AM 02

J. M. COUNTS, Dr.P.H., Chief

WATER QUALITY ANALYSIS - Chemical

SPECIMEN UNSATISFACTORY
Reason: _____ CODE

SPECIMEN NUMBER 42392 | SYSTEM NUMBER

NAME OF CLIENT EK Swanson | IDENTIFICATION NUMBER (17–24) VERIFIED DATE 8-3-83

ADDRESS BWOC

CITY Phx | STATE | ZIP CODE | COUNTY | CODE (15 16)

SOURCE TYPE (check one) ambient
☐ Well ☑ Surface ☐ Sewage ☐ Industrial ☐ Seepage

SOURCE DATA (check each applicable box)
☐ Public System ☐ Individual System
☐ Treated ☑ Untreated
☐ Routine Sample ☐ Re-Sample ☑ Special
☑ Grab Sample ☐ Composite Sample
☐ New Source ☑ Existing Source

LAB USE ONLY
Lab Performing Test: Phoenix - 1, Flagstaff - 2, Tucson - 3 (27)
DO NOT CHARGE (28)

MAILING ADDRESS OF REPORT
ADDRESS
CITY | STATE | ZIP CODE

FIELD DATA
Conductivity 590.4 Mhos D.O. 7.4 pH 8.2
Air Temp. 32 °C. Water Temp. 26 °C.
Well Depth _____ Static Water Level _____
Gage Height _____ Discharge _____ CFS
Depth to Surface _____ _____ GPM

SYSTEM OR SOURCE NAME Burro Creek | CITY Baydad | WELL NUMBER
LOCATION OF SAMPLING POINT Burro Creek above BLM campground | WELL NAME
COUNTY Mohave | TOWNSHIP | RANGE | SECTION | COLLECTED BY Rumple
LATITUDE | LONGITUDE | STATION NUMBER | DATE COLLECTED 6/14/82 | HOUR 0930
STORET NUMBER | CONTROL NUMBER BC011 | PRESERVATIVE ADDED? ☑ YES ☐ NO

SAMPLE APPEARANCE -
☑ Clear ☐ Turbid ☐ Silty ☐ Floating ☐ Other

WEATHER -
☑ Clear ☐ Cloudy ☐ Rain ☐ Snow ☐ Other

SAMPLER'S COMMENTS: includes ortho PO4 sample

		D	T	ME/L	Mg/L
10 ☑	ROUTINE WATER CHEMISTRY				589
11 ☐	Specific Resistance (OHMS)				1710
12 ☑	pH				8.5
13 ☑	CATIONS				
14 ☑	Calcium				42
15 ☑	Magnesium				19
16 ☑	Sodium				53
17 ☑	Iron (0.3)				<0.10
18 ☑	Copper (1.0)				<0.05
19 ☑	Manganese (0.05)				<0.05
20 ☑	Zinc (5.0)				<0.05
	Σ(+) = 6.1105				
21 ☑	ANIONS				
22 ☑	Alk P (CaCO3)				5.3
23 ☑	Alk MP (CaCO3)				132
24 ☑	Chloride (250)				4
25 ☑	Nitrate (45) NO3				3.54
26 ☑	Sulfate (250)				67.23
27 ☑	Total PO4 ortho P				<0.05
28 ☑	Fluorides				1.2
38 ☐	Nitrite				
	Σ(-) = 6.1614				

D - Dissolved T - Total

		Mg/L
29 ☐	Solids	
30 ☑	Residue	374
31 ☐	T.D.S. Calc.	
32 ☑	Hardness (CaCO3)	178
33 ☑	Total S.S.	<1
34 ☐	V.S.S.	
35 ☐	Surfactants	
36 ☐	B.O.D.	
37 ☐	C.O.D.	
39 ☑	Kjeldahl Nitrogen Total	0.2
40 ☑	Others K	9
	Sb	<0.010
	Mo	<0.010
	mass balance	

☐ Acceptable for Public Usage
☐ Provisionally Accepted for Public Usage*
☐ Rejected for Public Usage*
☐ Based on Parameters Run
*See attached for interpretation
Evaluated by _____
Bureau of Water Quality Control
Date _____

		D	T	Mg/L
41 ☑	TRACE METALS (Mg/l)			
42 ☑	Arsenic (01)(05)			<0.02
43 ☑	Silver (05)			<0.025
44 ☑	Chromium (0.05)			<0.010
45 ☑	Cadmium (0.01)			<0.005
46 ☑	Lead (0.05)			<0.02
47 ☑	Selenium (0.01)			<0.005
48 ☑	Mercury (.005)			<0.0005
50 ☑	SPECIAL			
49 ☑	Boron or ortho PO4-P			0.01
51 ☐	Radiological			12.0
52 ☐	Petroleum Res.			
53 ☐	C.C.E. (0.2)			
54 ☐	Phenols (0.001)			
55 ☐	Pesticides			
56 ☑	PHYSICAL			
☐	Color			
☐	Taste			
☐	Odor			
☑	Turbidity			2

COMMENTS _____

Analyst Ken Quantrupulos Date Reported 7-21-82

ADHS/DCS/Epidemiology and Laboratory Services 17 (5-76)

LABORATORY COPY

CIMEN SUBMITTING
) REPORTING FORM | 1 | 7 | (25, 26)

State of Arizona
Department of Health Services
State Laboratory

Date Rec'd. 3 8
JUN 21 11 28 AM '82
J. M. COUNTS, Dr. P.H. Chief

ATER QUALITY ANALYSIS - Chemical

SPECIMEN UNSATISFACTORY
Reason: _____ CODE

IMEN NUMBER	43602
SYSTEM NUMBER	
E OF CLIENT	E K Swanson
IDENTIFICATION NUMBER	
RESS	BWQC
	Phx
STATE	
ZIP CODE	
COUNTY	
CODE	

AB USE ONLY
b Performing Test
oenix - 1
gstaff - 2
cson - 3
27
O NOT CHARGE
28

MAILING ADDRESS OF REPORT
ADDRESS
CITY | STATE | ZIP CODE

TEM OR SOURCE NAME	Burro Creek Study
CITY	
WELL NUMBER	
ATION OF SAMPLING POINT	
WELL NAME	
NTY	
TOWNSHIP	
RANGE	
SECTION	
COLLECTED BY	
TUDE	
LONGITUDE	
STATION NUMBER	
DATE COLLECTED	
HOUR	
RET NUMBER	
CONTROL NUMBER	QC-2
PRESERVATIVE ADDED?	☐ YES ☐ NO

SOURCE TYPE (check one)
☐ Well ☐ Surface ☐ Sewage ☐ Industrial ☐ Seepage

SOURCE DATA (check each applicable box)
☐ Public System ☐ Treated ☐ Routine Sample
☐ Individual System ☐ Untreated ☐ Re-Sample
☐ Special
☐ Grab Sample ☐ New Source
☐ Composite Sample ☐ Existing Source

FIELD DATA -
Conductivity _____ Mhos D.O. _____ pH _____
Air Temp. _____ °C. Water Temp. _____ °C.
Well Depth _____ Static Water Level _____
Gage Height _____ Discharge _____ CFS
Depth to Surface _____ _____ GPM

SAMPLE APPEARANCE -
☐ Clear ☐ Turbid ☐ Silty ☐ Floating ☐ Other

WEATHER -
☐ Clear ☐ Cloudy ☐ Rain ☐ Snow ☐ Other

SAMPLER'S COMMENTS: _____

☑ ROUTINE WATER CHEMISTRY
☑ Specific Resistance (OHMS) 1720
☑ pH 8.5

☑ CATIONS	D	T	ME/L	Mg/L
☑ Calcium				39
☑ Magnesium				17
☑ Sodium				56
☑ Iron (0.3)				<0.10
☑ Copper (1.0)				<0.05
☑ Manganese (0.05)				<0.05
☑ Zinc (5.0)				<0.05
Σ(+)			6.0090	

☑ ANIONS	D	T	ME/L	Mg/L
☑ Alk P (CaCO3)				3.5
☑ Alk MP (CaCO3)				127.4
☑ Chloride (250)				46
☑ Nitrate (45)				1.24
☑ Sulfate (250)				75.41
☑ Total PO4				<0.05
☑ Fluorides				1.13
☐ Nitrite				
Σ(-) = 5.4947				

D Dissolved T - Total

	Mg/L
29 ☐ Solids	
30 ☑ Residue	368
31 ☐ T.D.S. Calc.	
32 ☑ Hardness (CaCO3)	168
33 ☑ Total S.S.	<1
34 ☐ V.S.S.	
35 ☐ Surfactants	
36 ☐ B.O.D.	
37 ☐ C.O.D.	
39 ☑ Kjeldahl Nitrogen Total	0.15
40 ☑ Others K	9
Sb	<0.010
Mo	<0.010
mass balance	

41 ☑ TRACE METALS (Mg/l)	D	T	Mg/L
42 ☑ Arsenic (.01)(.05)			<0.02
43 ☑ Silver (.05)			<0.005
44 ☑ Chromium (0.05)			<0.010
45 ☑ Cadmium (0.01)			<0.005
46 ☑ Lead (0.05)			<0.02
47 ☑ Selenium (0.01)			<0.005
48 ☑ Mercury (.005)			<0.0005
50 ☐ SPECIAL			
49 ☐ ~~Boron~~ Si			10.2
51 ☐ Radiological			
52 ☐ Petroleum Res.			
53 ☐ C.C.E. (0.2)			
54 ☐ Phenols (0.001)			
55 ☐ Pesticides			
56 ☑ PHYSICAL			
☐ Color			
☐ Taste			
☐ Odor			
☑ Turbidity			2

☐ Acceptable for Public Usage
☐ Provisionally Accepted for Public Usage*
☐ Rejected for Public Usage*
☐ Based on Parameters Run
*See attached for interpretation
Evaluated by _____
Bureau of Water Quality Control
Date _____

MMENTS _____

alyst Rose Ann Pasqualoni Date Reported 7/29/82

LABORATORY COPY

S/DCS/Epidemiology and Laboratory Services-77 (5-76)

SPECIMEN SUBMITTING AND REPORTING FORM 1 7 (25 26)

State of Arizona
Department of Health Services
State Laboratory

Date Rec'd. JAN 21 10 00 AM 82

J. M. DOUNTS, Dr.P.H., Chief

WATER QUALITY ANALYSIS - Chemical

VERIFIED

SPECIMEN UNSATISFACTORY
Reason: _____ CODE

SPECIMEN NUMBER A-592 | SYSTEM NUMBER

17 DATE 1-22-82 24 BY Myr

NAME OF CLIENT EK Swanson | IDENTIFICATION NUMBER

ADDRESS BWQC

CITY Phx | STATE | ZIP CODE | COUNTY | CODE (15 16)

SOURCE TYPE (check one) Ambient
☐ Well ☑ Surface ☐ Sewage ☐ Industrial ☐ Seepage

SOURCE DATA (check each applicable box)
☐ Public System ☐ Individual System
☐ Treated ☑ Untreated
☐ Routine Sample ☐ Re-Sample ☑ Special
☑ Grab Sample ☐ Composite Sample
☐ New Source ☑ Existing Source

LAB USE ONLY
Lab Performing Test
Phoenix - 1
Flagstaff - 2
Tucson - 3 (27)
DO NOT CHARGE (28)

MAILING ADDRESS OF REPORT
ADDRESS
CITY | STATE | ZIP CODE

FIELD DATA -
Conductivity 590µ Mhos D.O. 7.1 pH 8.6
Air Temp. 35 °C. Water Temp. 25.5 °C
Well Depth _____ Static Water Level _____
Gage Height _____ Discharge _____ CFS
Depth to Surface _____ _____ GPM

SYSTEM OR SOURCE NAME Burro Creek | CITY Bagdad | WELL NUMBER
LOCATION OF SAMPLING POINT Burro Creek below BLM campground | WELL NAME
COUNTY Yavapai | TOWNSHIP | RANGE | SECTION | COLLECTED BY Rumple
LATITUDE | LONGITUDE | STATION NUMBER | DATE COLLECTED 1/19/82 | HOUR 1015
STORET NUMBER | CONTROL NUMBER BC010 | PRESERVATIVE ADDED? ☑ YES ☐ NO

SAMPLE APPEARANCE -
☑ Clear ☐ Turbid ☐ Silty ☐ Floating ☐ Other

WEATHER -
☑ Clear ☐ Cloudy ☐ Rain ☐ Snow ☐ Other

SAMPLER'S COMMENTS: includes ortho PO4 sample

	D	T	ME/L	Mg/L
10 ☑ ROUTINE WATER CHEMISTRY				571
11 ☑ Specific Resistance (OHMS)				1750
12 ☑ pH				8.5
13 ☑ CATIONS				
14 ☑ Calcium				46
15 ☑ Magnesium				14
16 ☑ Sodium				54
17 ☑ Iron (0.3)				<0.1
18 ☑ Copper (1.0)				<0.05
19 ☑ Manganese (0.05)				<0.05
20 ☑ Zinc (5.0)				<0.05
Σ (+)			5.125	
21 ☑ ANIONS				
22 ☑ Alk-P (CaCO3)				5.3
23 ☑ Alk MP (CaCO3)				125.7
24 ☑ Chloride (250)				45
25 ☑ Nitrate (45) NO3				1.37
26 ☑ Sulfate (250)				74.2
27 ☑ Total PO4 -T				<0.05
28 ☑ Fluorides				1.05
38 ☐ Nitrite				
Σ (-)			5.445	

D - Dissolved T - Total

	Mg/L
29 ☐ Solids	
30 ☑ Residue	335
31 ☐ T.D.S. Calc.	
32 ☑ Hardness (CaCO3)	176
33 ☑ Total S.S.	1
34 ☐ V.S.S.	
35 ☐ Surfactants	
36 ☐ B.O.D.	
37 ☐ C.O.D.	
39 ☑ Kjeldahl Nitrogen Total	
40 ☑ Others K	9
Sb	<0.010
Mo	0.015
mass balance	

☐ Acceptable for Public Usage
☐ Provisionally Accepted for Public Usage*
☐ Rejected for Public Usage*
☐ Based on Parameters Run
*See attached for interpretation
Evaluated by _____
Bureau of Water Quality Control
Date _____

	D	T	Mg/L
41 ☑ TRACE METALS (Mg/l)			
42 ☑ Arsenic (.01) (.05)			<0.02
43 ☑ Silver (.05)			<0.025
44 ☑ Chromium (0.05)			<0.010
45 ☑ Cadmium (0.01)			<0.025
46 ☑ Lead (0.05)			<0.02
47 ☑ Selenium (0.01)			<0.005
48 ☑ Mercury (.005)			<0.0005
50 ☑ SPECIAL			
49 ☐ ~~Boron~~ ortho-P			<0.01
51 ☐ ~~Radiological~~ Si			10.2
52 ☐ Petroleum Res.			
53 ☐ C C E (0.2)			
54 ☐ Phenols (0.001)			
55 ☐ Pesticides			
56 ☑ PHYSICAL			
☐ Color			
☐ Taste			
☐ Odor			
☑ Turbidity			2

COMMENTS _____

Analyst Rosa Ann Fayerbend Date Reported 2/2/82

ADHS - DCS - Epidemiology and Laboratory Services 17 (5 78)

LABORATORY COPY

CIMEN SUBMITTING REPORTING FORM 11 7 (25 26)

State of Arizona
Department of Health Services
State Laboratory

Date Rec'd. (3 8)

J. M. COUNTS, Dr.P.H., Chief

ATER QUALITY ANALYSIS - Chemical

SPECIMEN UNSATISFACTORY
Reason: _____ CODE

MEN NUMBER | SYSTEM NUMBER | Ath. Tohx Route (24)

OF CLIENT: F.F. Simon | IDENTIFICATION NUMBER

ESS: BWQC

PK | STATE | ZIP CODE | COUNTY | CODE (15 16)

SOURCE TYPE (check one) surface
☐ Well ☑ Surface ☐ Sewage ☐ Industrial ☐ Seepage

SOURCE DATA (check each applicable box)
☐ Public System ☐ Individual System
☐ Treated ☑ Untreated
☐ Routine Sample ☐ Re-Sample ☐ Special
☑ Grab Sample ☐ Composite Sample
☐ New Source ☑ Existing Source

AB USE ONLY
Performing Test
henix - 1
gstaff - 2
son - 3 (27)
O NOT CHARGE (28)

MAILING ADDRESS OF REPORT
ADDRESS
CITY | STATE | ZIP CODE

FIELD DATA - none
Conductivity _____ Mhos D.O. _____ pH _____
Air Temp. _____ °C. Water Temp. _____ °C.
Well Depth _____ Static Water Level _____
Gage Height _____ Discharge _____ CFS
Depth to Surface _____ _____ GPM

EM OR SOURCE NAME: Lake Content | CITY: Bonita | WELL NUMBER
TION OF SAMPLING POINT: Dam | WELL NAME

TY | TOWNSHIP | RANGE | SECTION | COLLECTED BY: Romero

UDE | LONGITUDE | STATION NUMBER | DATE COLLECTED | HOUR

ET NUMBER | CONTROL NUMBER: QC-L | PRESERVATIVE ADDED? ☑ YES ☐ NO

SAMPLE APPEARANCE -
☐ Clear ☐ Turbid ☐ Silty ☐ Floating ☐ Other

WEATHER -
☐ Clear ☐ Cloudy ☐ Rain ☐ Snow ☐ Other

SAMPLER'S COMMENTS: no outlet Dam Romero

	D	T	ME/L	Mg/L
☐ ROUTINE WATER CHEMISTRY				
Specific Resistance (OHMS) 6230				
pH 7.6				
☐ CATIONS				
Calcium				16
Magnesium				41
Sodium				<10.0
Iron (0.3)				4.55
Copper (1.0)				0.013
Manganese (0.05)				0.07
Zinc (5.0)				<0.05
			Σ(+) 1.217	
☐ ANIONS				
Alk P (CaCO3)				0
Alk MP (CaCO3)				44.8
Chloride (250)				3
Nitrate (45) NO3				0.53
Sulfate (250)				17.7
Total PO4 as P				<.05
Fluorides				0.35
Nitrite				
			Σ(-) 1.3961	

D - Dissolved T - Total

	Mg/L
29 ☐ Solids	
30 ☑ Residue	125
31 ☐ T.D.S. Calc.	
32 ☑ Hardness (CaCO3)	56
33 ☐ Total S.S.	48
34 ☐ V.S.S.	
35 ☐ Surfactants	
36 ☐ B.O.D.	
37 ☐ C.O.D.	
39 ☑ Kjeldahl Nitrogen Total	1.9
40 ☑ Others N	3.3
Si	<0.01
Mg	0.011
SiO2 - Si	26.0

	D	T	Mg/L
41 ☐ TRACE METALS (Mg/l)			
42 ☐ Arsenic (.01) (.05)			<0.02
43 ☐ Silver (.05)			<0.005
44 ☐ Chromium (0.05)			<0.01
45 ☐ Cadmium (0.01)			<0.005
46 ☑ Lead (0.05)			<0.02
47 ☐ Selenium (0.01)			<0.005
48 ☑ Mercury (.005)			<0.0005
50 ☐ SPECIAL			
49 ☐ Boron			
51 ☐ Radiological			
52 ☐ Petroleum Res.			
53 ☐ C.C.E. (0.2)			
54 ☐ Phenols (0.001)			
55 ☐ Pesticides			
56 ☐ PHYSICAL			
☐ Color			
☐ Taste			
☐ Odor			
☐ Turbidity			44

☐ Acceptable for Public Usage
☐ Provisionally Accepted for Public Usage*
☐ Rejected for Public Usage*
☐ Based on Parameters Run
*See attached for interpretation

Evaluated by _____
Bureau of Water Quality Control
Date _____

COMMENTS: [illegible]

Analyst [illegible] Date Reported 1/16/73

DCS/Epidemiology and Laboratory Services-17 (5-76)

BWQ FILE COPY

SPECIMEN SUBMITTING AND REPORTING FORM 17 (25 26)

State of Arizona
Department of Health Services
State Laboratory

Date Rec'd. DEC 13 9 46 AM '82

J. M. COUNTS, Dr.P.H., Chief

WATER QUALITY ANALYSIS - Chemical

CODED TSM 2-22-83 VERIFIED

SPECIMEN UNSATISFACTORY Reason: _____ DATE _____ BY _____ CODE

SPECIMEN NUMBER 17905 | SYSTEM NUMBER

NAME OF CLIENT E K Swanson | IDENTIFICATION NUMBER (17–24)

ADDRESS BLKC

CITY Phx | STATE | ZIP CODE | COUNTY | CODE (15 16)

SOURCE TYPE (check one) ambient
☐ Well ☑ Surface ☐ Sewage ☐ Industrial ☐ Seepage

SOURCE DATA (check each applicable box)
☐ Public System ☐ Individual System
☐ Treated ☑ Untreated
☐ Routine Sample ☐ Re-Sample ☑ Special
☑ Grab Sample ☐ Composite Sample
☐ New Source ☑ Existing Source

LAB USE ONLY
Lab Performing Test
Phoenix - 1 Flagstaff - 2 Tucson - 3 (27)
DO NOT CHARGE (28)

MAILING ADDRESS OF REPORT
ADDRESS
CITY | STATE | ZIP CODE

FIELD DATA -
Conductivity 1404 Mhos D.O. 12.2 pH 7.43
Air Temp. 22 °C. Water Temp. 8.8 °C
Well Depth _____ Static Water Level _____
Gage Height _____ Discharge _____ CFS
Depth to Surface _____ _____ GPM

SYSTEM OR SOURCE NAME Burro Creek | CITY Bagdad | WELL NUMBER
LOCATION OF SAMPLING POINT Burro Creek below Boulder Creek | WELL NAME
COUNTY Yavapai | TOWNSHIP | RANGE | SECTION | COLLECTED BY Rampe
LATITUDE | LONGITUDE | STATION NUMBER BC013 | DATE COLLECTED 12-11-82 | HOUR 1400
STORET NUMBER | CONTROL NUMBER R0131 | PRESERVATIVE ADDED? ☑ YES ☐ NO

SAMPLE APPEARANCE -
☐ Clear ☑ Turbid ☐ Silty ☐ Floating ☐ Other

WEATHER -
☑ Clear ☐ Cloudy ☐ Rain ☐ Snow ☐ Other

SAMPLER'S COMMENTS: includes ortho PO4 sample

		D	T	ME/L	Mg/L
10 ☑	ROUTINE WATER CHEMISTRY				
11 ☑	Specific Resistance (OHMS)				6280 159
12 ☑	pH				7.6
13 ☑	CATIONS				
14 ☑	Calcium				17
15 ☑	Magnesium				3
16 ☑	Sodium				<10.0
17 ☑	Iron (0.3)				4.65
18 ☑	Copper (1.0)				0.027
19 ☑	Manganese (0.05)				0.08
20 ☑	Zinc (5.0)				<0.05
				Σ(+) 1.1797	
21 ☑	ANIONS				
22 ☑	Alk P (CaCO3)				0
23 ☑	Alk MP (CaCO3)				44.8
24 ☑	Chloride (250)				2
25 ☑	Nitrate (45) NO_3				0.49
26 ☑	Sulfate (250)				17.8
27 ☑	Total PO4 -P				<0.05
28 ☑	Fluorides				0.33
38 ☐	Nitrite				
				Σ(-) 1.3483	

D - Dissolved T - Total

		Mg/L
29 ☐	Solids	
30 ☑	Residue	126
31 ☐	T.D.S. Calc.	
32 ☑	Hardness (CaCO3)	56
33 ☑	Total S.S.	59
34 ☑	V.S.S.	
35 ☐	Surfactants	
36 ☐	B.O.D.	
37 ☐	C.O.D.	
39 ☑	Kjeldahl Nitrogen Total	1.0
40 ☑	Others N	3.3
	Sb	<0.01
	As	<0.01
	SiO_2 - Si	27.5

☐ Acceptable for Public Usage
☐ Provisionally Accepted for Public Usage*
☐ Rejected for Public Usage*
☐ Based on Parameters Run
*See attached for interpretation
Evaluated by _____
Bureau of Water Quality Control
Date _____

		D	T	Mg/L
41 ☑	TRACE METALS (Mg/l)			
42 ☑	Arsenic (.01)(.05)			<0.02
43 ☑	Silver (.05)			<0.005
44 ☑	Chromium (0.05)			<0.010
45 ☑	Cadmium (0.01)			<0.005
46 ☑	Lead (0.05)			<0.02
47 ☑	Selenium (0.01)			<0.005
48 ☑	Mercury (.005)			<0.0005
50 ☑	SPECIAL			
49 ☑	~~Boron~~ ortho PO4 -P			0.10
51 ☐	Radiological			
52 ☐	Petroleum Res.			
53 ☐	C.C.E. (0.2)			
54 ☐	Phenols (0.001)			
55 ☐	Pesticides			
56 ☐	PHYSICAL			
☐	Color			
☐	Taste			
☐	Odor			
☑	Turbidity			44

COMMENTS run mass balance

Analyst Barbara Ohmart Date Reported 1/26/83

ADHS/DCS/Epidemiology and Laboratory Services-17 (5-76)

LABORATORY COPY

CIMEN SUBMITTING REPORTING FORM | 1 | 7 | (25 26)

State of Arizona
Department of Health Services
State Laboratory

Date Rec'd. (3 8) DEC 16 11 AM '82

J. M. COUNTS, Dr.P.H., Chief

ATER QUALITY ANALYSIS - Chemical

SPECIMEN UNSATISFACTORY
Reason: _____ CODE

MEN NUMBER | SYSTEM NUMBER

OF CLIENT: E K Swanson (17) | IDENTIFICATION NUMBER (24)

ESS: Buoc

	STATE	ZIP CODE	COUNTY	CODE (15 16)
Dkx				

SOURCE TYPE (check one)
☐ Well ☐ Surface ☐ Sewage ☐ Industrial ☐ Seepage

SOURCE DATA (check each applicable box)
☐ Public System ☐ Individual System
☐ Treated ☐ Untreated
☐ Routine Sample ☐ Re-Sample ☐ Special
☐ Grab Sample ☐ Composite Sample
☐ New Source ☐ Existing Source

B USE ONLY
Performing Test
nix - 1
staff - 2
on - 3 (27)
NOT CHARGE (28)

MAILING ADDRESS OF REPORT

ADDRESS

CITY | STATE | ZIP CODE

M OR SOURCE NAME | CITY | WELL NUMBER

ION OF SAMPLING POINT | WELL NAME

Y | TOWNSHIP | RANGE | SECTION | COLLECTED BY

DE | LONGITUDE | STATION NUMBER | DATE COLLECTED: 12 | HOUR

T NUMBER | CONTROL NUMBER: QC-2 | PRESERVATIVE ADDED? ☐ YES ☐ NO

FIELD DATA -
Conductivity _____ Mhos D.O. _____ pH _____
Air Temp. _____ °C. Water Temp. _____ °C.
Well Depth FROM C. Static Water Level _____
Gage Height _____ Discharge _____ CFS
Depth to Surface _____ _____ GPM

SAMPLE APPEARANCE -
☐ Clear ☐ Turbid ☐ Silty ☐ Floating ☐ Other

WEATHER -
☐ Clear ☐ Cloudy ☐ Rain ☐ Snow ☐ Other

SAMPLER'S COMMENTS: _____

☐ ROUTINE WATER CHEMISTRY
Specific Resistance (OHMS) 8260
pH 7.11

☐ CATIONS	D	T	ME/L	Mg/L
Calcium				10
Magnesium				3
Sodium				<10.0
Iron (0.3)				2.00
Copper (1.0)				0.02
Manganese (0.05)				<0.05
Zinc (5.0)				<0.05
			Σ(+) 0.7917	
☐ ANIONS				
Alk P (CaCO3)				0
Alk MP (CaCO3)				29.9
Chloride (250)				1
Nitrate (45) NO3				<0.1
Sulfate (250)				14.2
Total PO4 - P				<0.05
Fluorides				0.72
Nitrite				
			Σ(-) 0.7599	

	Mg/L
29 ☐ Solids	
30 ☐ Residue	108
31 ☐ T.D.S: Calc.	
32 ☐ Hardness (CaCO3)	38
33 ☐ Total S.S.	8
34 ☐ V.S.S.	
35 ☐ Surfactants	
36 ☐ B.O.D.	
37 ☐ C.O.D.	
39 ☐ Kjeldahl Nitrogen Total	1.1
40 ☐ Others K	1.8
Si	<0.01
Mo	<0.01
SiO2 - Si	15.2

41 ☐ TRACE METALS (Mg/l)	D	T	Mg/L
42 ☐ Arsenic (.01) (.05)			<0.02
43 ☐ Silver (.05)			<0.005
44 ☐ Chromium (0.05)			<0.01
45 ☐ Cadmium (0.01)			<0.005
46 ☐ Lead (0.05)			<0.02
47 ☐ Selenium (0.01)			<0.005
48 ☐ Mercury (.005)			<0.0005
50 ☐ SPECIAL			
49 ☐ Boron			
51 ☐ Radiological			
52 ☐ Petroleum Res.			
53 ☐ C.C.E. (0.2)			
54 ☐ Phenols (0.001)			
55 ☐ Pesticides			
56 ☐ PHYSICAL			
☐ Color			
☐ Taste			
☐ Odor			
☐ Turbidity			28

☐ Acceptable for Public Usage
☐ Provisionally Accepted for Public Usage*
☐ Rejected for Public Usage*
☐ Based on Parameters Run
*See attached for interpretation

Evaluated by _____
Bureau of Water Quality Control
Date _____

olved T - Total

IMENTS Total Hardness Reported

Dr. Bruce Wilcox
it

Date Reported 1/6/83

CS/Epidemiology and Laboratory Services-17 (5-76)

BWQ FILE COPY

SPECIMEN SUBMITTING AND REPORTING FORM 1 7 (25 26) DATE 6-7-82 BY [illegible]

VERIFIED

State of Arizona
Department of Health Services
State Laboratory

Date Rec'd. [illegible] (3)

J. M. COUNTS, Dr.P.H., Chief

WATER QUALITY ANALYSIS - Chemical

CODED

SPECIMEN UNSATISFACTORY
Reason: _____ CODE

SPECIMEN NUMBER 1842 | SYSTEM NUMBER | (17) DATE 2-25-83 BY TJM (24)

NAME OF CLIENT EK Swanson | IDENTIFICATION NUMBER

ADDRESS BWCC

CITY Phx | STATE | ZIP CODE | COUNTY | CODE (15 16)

SOURCE TYPE (check one) ambient
☐ Well ☑ Surface ☐ Sewage ☐ Industrial ☐ Seepage

SOURCE DATA (check each applicable box)
☐ Public System ☐ Individual System
☐ Treated ☑ Untreated
☐ Routine Sample ☐ Re-Sample ☑ Special
☑ Grab Sample ☐ Composite Sample
☐ New Source ☑ Existing Source

LAB USE ONLY
Lab Performing Test
Phoenix - 1
Flagstaff - 2
Tucson - 3 (27)
DO NOT CHARGE (28)

MAILING ADDRESS OF REPORT

ADDRESS

CITY | STATE | ZIP CODE

FIELD DATA -
Conductivity 98 Mhos D.O. 12.2 pH 7.28
Air Temp. 22 °C. Water Temp. 5.5 °C.
Well Depth _____ Static Water Level _____
Gage Height _____ Discharge _____ CFS
Depth to Surface _____ _____ GPM

SAMPLE APPEARANCE -
☐ Clear ☑ Turbid ☐ Silty ☐ Floating ☐ Other

WEATHER -
☑ Clear ☐ Cloudy ☐ Rain ☐ Snow ☐ Other

SAMPLER'S COMMENTS: no ortho PO4 sample

SYSTEM OR SOURCE NAME Boulder Creek | CITY Baghdad | WELL NUMBER

LOCATION OF SAMPLING POINT Boulder Creek below mid-hillside tailings

COUNTY Yavapai | TOWNSHIP | RANGE | SECTION | COLLECTED BY Rapp

LATITUDE | LONGITUDE | STATION NUMBER R1028 | DATE COLLECTED 12-2-82 | HOUR 1100

STORET NUMBER | CONTROL NUMBER R022 | PRESERVATIVE ADDED? ☑ YES ☐ NO

	D	T	ME/L	Mg/L
10 ☑ ROUTINE WATER CHEMISTRY 120				
11 ☑ Specific Resistance (OHMS) 8320				
12 ☑ pH 7.3				
13 ☑ CATIONS				
14 ☑ Calcium				11
15 ☑ Magnesium				2
16 ☑ Sodium				<10.0
17 ☑ Iron (0.3)				1.98
18 ☑ Copper (1.0)				<0.01
19 ☑ Manganese (0.05)				<0.05
20 ☑ Zinc (5.0)				<0.05
			Σ(+) 0.75-94	
21 ☑ ANIONS				
22 ☑ Alk P (CaCO3)				0
23 ☑ Alk MP (CaCO3)				28.2
24 ☑ Chloride (250)				2
25 ☑ Nitrate (45) NO3				<0.4
26 ☑ Sulfate (250)				14.6
27 ☑ Total PO4 -P				<0.05
28 ☑ Fluorides				0.81
38 ☐ Nitrite				
			Σ(-) 0.7670	

D - Dissolved T - Total

	Mg/L
29 ☐ Solids	
30 ☑ Residue	102
31 ☐ T.D.S. Calc.	
32 ☑ Hardness (CaCO3)	36
33 ☑ Total S.S.	7
34 ☐ V.S.S.	
35 ☐ Surfactants	
36 ☐ B.O.D.	
37 ☐ C.O.D.	
39 ☑ Kjeldahl Nitrogen Total	0.7
40 ☑ Others K	1.8
Sb	<0.01
Mo	<0.01
SiO_2 -Si	15.2

☐ Acceptable for Public Usage
☐ Provisionally Accepted for Public Usage*
☐ Rejected for Public Usage*
☐ Based on Parameters Run
*See attached for interpretation
Evaluated by _____
Bureau of Water Quality Control
Date _____

	D	T	Mg/L
41 ☑ TRACE METALS (Mg/l)			
42 ☑ Arsenic (.01)(.05)			<0.02
43 ☑ Silver (.05)			<0.005
44 ☑ Chromium (0.05)		✓	<0.01
45 ☑ Cadmium (0.01)			<0.005
46 ☑ Lead (0.05)			<0.02
47 ☑ Selenium (0.01)			<0.005
48 ☑ Mercury (.005)			<0.0005
50 ☐ SPECIAL			
49 ☐ Boron			
51 ☐ Radiological			
52 ☐ Petroleum Res.			
53 ☐ C.C.E. (0.2)			
54 ☐ Phenols (0.001)			
55 ☐ Pesticides			
56 ☑ PHYSICAL			
☐ Color			
☐ Taste			
☐ Odor			
☑ Turbidity			28

COMMENTS run mass balance

Analyst Barbara Olmsted Date Reported 2/2/83 Barbara for OMC

ADHS/DCS/Epidemiology and Laboratory Services-17 (5-76)

LABORATORY COPY

CIMEN SUBMITTING
REPORTING FORM | 1 | 7 | (25, 26)

State of Arizona
Department of Health Services
State Laboratory

Date Rec'd. (3–8)

J.M. COUNTS, Dr.P.H., Chief

ATER QUALITY ANALYSIS - Chemical

SPECIMEN UNSATISFACTORY
Reason: _____ CODE

MEN NUMBER | SYSTEM NUMBER

OF CLIENT: E K Sutton | IDENTIFICATION NUMBER (17–24)

ESS: BWQC

	STATE	ZIP CODE	COUNTY	CODE (15–16)
Phx				

B USE ONLY
Performing Test
enix - 1
gstaff - 2
son - 3 (27)
NOT CHARGE (28)

MAILING ADDRESS OF REPORT
ADDRESS
CITY | STATE | ZIP CODE

M OR SOURCE NAME | CITY | WELL NUMBER
TION OF SAMPLING POINT | WELL NAME
TY | TOWNSHIP | RANGE | SECTION | COLLECTED BY
UDE | LONGITUDE | STATION NUMBER | DATE COLLECTED: 12 | HOUR
ET NUMBER | CONTROL NUMBER: QC-3 | PRESERVATIVE ADDED? ☐ YES ☐ NO

SOURCE TYPE (check one)
☐ Well ☐ Surface ☐ Sewage ☐ Industrial ☐ Seepage

SOURCE DATA (check each applicable box)
☐ Public System ☐ Treated ☐ Routine Sample
☐ Individual System ☐ Untreated ☐ Re-Sample
☐ Special
☐ Grab Sample ☐ New Source
☐ Composite Sample ☐ Existing Source

FIELD DATA -
Conductivity _____ Mhos D.O. _____ pH _____
Air Temp. 100 °C. Water Temp. _____ °C.
Well Depth _____ Static Water Level _____
Gage Height _____ Discharge _____ CFS
Depth to Surface _____ _____ GPM

SAMPLE APPEARANCE -
☐ Clear ☐ Turbid ☐ Silty ☐ Floating ☐ Other

WEATHER -
☐ Clear ☐ Cloudy ☐ Rain ☐ Snow ☐ Other

SAMPLER'S COMMENTS: _____

☐ ROUTINE WATER CHEMISTRY
☐ Specific Resistance (OHMS) 3170
☐ pH 7.9

☐ CATIONS	D	T	ME/L	Mg/L
Calcium				26
Magnesium				7
Sodium				21.2
Iron (0.3)				1.32
Copper (1.0)				<0.01
Manganese (0.05)				<0.05
Zinc (5.0)				<0.05
			E(+) 2.8971	
☐ ANIONS				
Alk P (CaCO3)				0
Alk MP (CaCO3)				79.7
Chloride (250)				9
Nitrate (45) NO				0.58
Sulfate (250)				27.2
Total PO4 P				0.05
Fluorides				0.60
Nitrite				
			E(-) 2.4591	

	Mg/L
29 ☐ Solids	
30 ☐ Residue	2.09
31 ☐ T.D.S. Calc.	
32 ☐ Hardness (CaCO3)	96
33 ☐ Total S.S.	13
34 ☐ V.S.S.	
35 ☐ Surfactants	
36 ☐ B.O.D.	
37 ☐ C.O.D.	
39 ☐ Kjeldahl Nitrogen Total	1.0
40 ☐ Others K	4.0
Sb	<0.01
Mo	<0.01
SiO2 Si	18.3

41 ☐ TRACE METALS (Mg/l)	D	T	Mg/L
42 ☐ Arsenic (.01)(.05)			<0.02
43 ☐ Silver (.05)			<0.005
44 ☐ Chromium (0.05)		✓	<0.01
45 ☐ Cadmium (0.01)			<0.005
46 ☐ Lead (0.05)			<0.02
47 ☐ Selenium (0.01)			<0.005
48 ☐ Mercury (.005)			<0.0005
50 ☐ SPECIAL			
49 ☐ Boron			
51 ☐ Radiological			
52 ☐ Petroleum Res.			
53 ☐ C.C.E. (0.2)			
54 ☐ Phenols (0.001)			
55 ☐ Pesticides			
56 ☐ PHYSICAL			
☐ Color			
☐ Taste			
☐ Odor			
☐ Turbidity			22

☐ Acceptable for Public Usage
☐ Provisionally Accepted for Public Usage*
☐ Rejected for Public Usage*
☐ Based on Parameters Run
*See attached for interpretation

Evaluated by _____
Bureau of Water Quality Control
Date _____

ssolved T - Total

MMENTS run mass balance

nyst Barbara Olney Date Reported 4/1/83

BWQ FILE COPY

HDCS/Epidemiology and Laboratory Services-17 (5-76)

SPECIMEN SUBMITTING AND REPORTING FORM 17 (25 26)

State of Arizona
Department of Health Services
State Laboratory

Date Rec'd 2-24-83 (3 8)

VERIFIED

J. M. COUNTS, Dr.P.H., Chief

WATER QUALITY ANALYSIS - Chemical

SPECIMEN UNSATISFACTORY
Reason: DATE 9-22-83 BY [illegible]
CODE

SPECIMEN NUMBER: 843
SYSTEM NUMBER:
(17 2-24-83 24) DM

NAME OF CLIENT: EK Swanson
IDENTIFICATION NUMBER:

ADDRESS: BLM

CITY: Phx | STATE | ZIP CODE | COUNTY | CODE (15 16)

SOURCE TYPE (check one) Ambient
☐ Well ☑ Surface ☐ Sewage ☐ Industrial ☐ Seepage

SOURCE DATA (check each applicable box)
☐ Public System ☐ Individual System
☐ Treated ☑ Untreated
☐ Grab Sample ☐ Composite Sample
☐ New Source ☑ Existing Source
☐ Routine Sample ☐ Re-Sample ☑ Special

LAB USE ONLY
Lab Performing Test
Phoenix - 1 / Flagstaff - 2 / Tucson - 3 (27)
DO NOT CHARGE (28)

MAILING ADDRESS OF REPORT
ADDRESS
CITY | STATE | ZIP CODE

FIELD DATA
Conductivity 300 / 20 Mhos D.O. 12.4 pH 8.12
Air Temp. 20 °C. Water Temp. 7.3 °C.
Well Depth ____ Static Water Level ____
Gage Height ____ Discharge ____ CFS
Depth to Surface ____ ____ GPM

SAMPLE APPEARANCE -
☐ Clear ☑ Turbid ☐ Silty ☐ Floating ☐ Other

WEATHER -
☑ Clear ☐ Cloudy ☐ Rain ☐ Snow ☐ Other

SAMPLER'S COMMENTS: includes ortho PO4 sample

SYSTEM OR SOURCE NAME: Burro Creek | CITY: Wickieup | WELL NUMBER:
LOCATION OF SAMPLING POINT: Burro Creek below BLM G-G | WELL NAME:
COUNTY: Mohave | TOWNSHIP | RANGE | SECTION | COLLECTED BY: Ramp
LATITUDE | LONGITUDE | STATION NUMBER: BC010 | DATE COLLECTED: 2-13-83 | HOUR: 1120
STORET NUMBER | CONTROL NUMBER: R028 | PRESERVATIVE ADDED? ☑ YES ☐ NO

		D	T	ME/L	Mg/L
10 ☑	ROUTINE WATER CHEMISTRY				
11 ☑	Specific Resistance (OHMS)				3210 (31)
12 ☑	pH				7.8
13 ☑	CATIONS				
14 ☑	Calcium				26
15 ☑	Magnesium				8
16 ☑	Sodium				21.7
17 ☑	Iron (0.3)				1.34
18 ☑	Copper (1.0)				0.027
19 ☑	Manganese (0.05)				<0.05
20 ☑	Zinc (5.0)				<0.05
				Σ(+) 3.0011	
21 ☑	ANIONS				
22 ☑	Alk P (CaCO3)				0
23 ☑	Alk MP (CaCO3)				81.3
24 ☑	Chloride (250)				9
25 ☑	Nitrate (45) -NO3				0.58
26 ☑	Sulfate (250)				26.7
27 ☑	Total PO4 -P				<0.05
28 ☑	Fluorides				0.67
38 ☐	Nitrite				
				Σ(-) 2.4803	

D - Dissolved T - Total

		Mg/L
29 ☐	Solids	
30 ☑	Residue	204
31 ☐	T.D.S. Calc.	
32 ☑	Hardness (CaCO3)	100
33 ☑	Total S.S.	11
34 ☐	V.S.S.	
35 ☐	Surfactants	
36 ☐	B.O.D.	
37 ☐	C.O.D.	
39 ☑	Kjeldahl Nitrogen Total	0.78
40 ☑	Others K	4.0
	Se	<0.01
	Mo	0.024
	SiO2 -Si	18.3

☐ Acceptable for Public Usage
☐ Provisionally Accepted for Public Usage*
☐ Rejected for Public Usage*
☐ Based on Parameters Run
*See attached for interpretation
Evaluated by ____
Bureau of Water Quality Control
Date ____

		D	T	Mg/L
41 ☑	TRACE METALS (Mg/l)			
42 ☑	Arsenic (.01) (.05)			<0.02
43 ☑	Silver (.05)			<0.005
44 ☑	Chromium (0.05)			<0.01
45 ☑	Cadmium (0.01)			<0.005
46 ☑	Lead (0.05)			<0.02
47 ☑	Selenium (0.01)			<0.005
48 ☑	Mercury (.005)			<0.0005
50 ☑	SPECIAL			
49 ☑	~~Boron~~ ortho PO4 -P			0.05
51 ☐	Radiological			
52 ☐	Petroleum Res.			
53 ☐	C.C.E. (0.2)			
54 ☐	Phenols (0.001)			
55 ☐	Pesticides			
56 ☐	PHYSICAL			
	Color			
	Taste			
	Odor			
☑	Turbidity			22

COMMENTS run mass balance

Analyst Richard Olmsen Date Reported 1/26/83

ADHS/DCS/Epidemiology and Laboratory Services-17 (5-76)

LABORATORY COPY

CIMEN SUBMITTING REPORTING FORM | 1 | 7 | (25, 26)

State of Arizona
Department of Health Services
State Laboratory

Date Rec'd. DEC 16 11 28 AM '82 (3, 8)
J. M. COUNTS, Dr.P.H., Chief

ATER QUALITY ANALYSIS - Chemical

SPECIMEN UNSATISFACTORY
Reason: _____ CODE

MEN NUMBER | SYSTEM NUMBER

OF CLIENT: E K Swanson | IDENTIFICATION NUMBER (17, 24)

ESS: BWQC

	STATE	ZIP CODE	COUNTY	CODE (15, 16)
12x				

AB USE ONLY
Performing Test
enix - 1
gstaff - 2
son - 3 (27)
NOT CHARGE (28)

MAILING ADDRESS OF REPORT
ADDRESS
CITY | STATE | ZIP CODE

EM OR SOURCE NAME | CITY | WELL NUMBER
TION OF SAMPLING POINT | WELL NAME
TY | TOWNSHIP | RANGE | SECTION | COLLECTED BY
UDE | LONGITUDE | STATION NUMBER | DATE COLLECTED: 12 | HOUR
ET NUMBER | CONTROL NUMBER: QC-4 | PRESERVATIVE ADDED? ☐ YES ☐ NO

SOURCE TYPE (check one)
☐ Well ☐ Surface ☐ Sewage ☐ Industrial ☐ Seepage

SOURCE DATA (check each applicable box)
☐ Public System ☐ Treated ☐ Routine Sample
☐ Individual System ☐ Untreated ☐ Re-Sample
☐ Grab Sample ☐ New Source ☐ Special
☐ Composite Sample ☐ Existing Source

FIELD DATA -
Conductivity _____ Mhos D.O. _____ pH _____
Air Temp. NO °C. Water-Temp. _____ °C.
Well Depth _____ Static Water Level _____
Gage Height _____ Discharge _____ CFS
Depth to Surface _____ _____ GPM

SAMPLE APPEARANCE -
☐ Clear ☐ Turbid ☐ Silty ☐ Floating ☐ Other

WEATHER -
☐ Clear ☐ Cloudy ☐ Rain ☐ Snow ☐ Other

SAMPLER'S COMMENTS: _____

☑ ROUTINE WATER CHEMISTRY
☑ Specific Resistance (OHMS) 3410
☑ pH 7.9

☑ CATIONS	D	T	ME/L	Mg/L
☑ Calcium				27
☑ Magnesium				9
☑ Sodium				16.4
☑ Iron (0.3)				0.33
☑ Copper (1.0)				<0.01
☑ Manganese (0.05)				<0.05
☑ Zinc (5.0)				<0.05
			Σ(+) 2.8777	
☑ ANIONS				
☑ Alk P (CaCO3)				0
☑ Alk MP (CaCO3)				94.6
☑ Chloride (250)				6
☑ Nitrate (45) NO3				0.66
☑ Sulfate (250)				11.5
☑ Total PO4 -P				0.05
☑ Fluorides				0.25
☑ Nitrite				
			Σ(-) 2.3244	

	Mg/L
29 ☐ Solids	
30 ☑ Residue	187
31 ☐ T.D.S. Calc.	
32 ☑ Hardness (CaCO3)	104
33 ☑ Total S.S.	4
34 ☐ V.S.S.	
35 ☐ Surfactants	
36 ☐ B.O.D.	
37 ☐ C.O.D.	
39 ☐ Kjeldahl Nitrogen Total	2.4
40 ☑ Others K	3.8
Sb	<0.01
Mo	<0.01
SiO2 -Si	19.8

41 ☑ TRACE METALS (Mg/l)	D	T	Mg/L
42 ☑ Arsenic (.01)(.05)			<0.02
43 ☑ Silver (.05)			<0.005
44 ☑ Chromium (0.05)		✓	<0.01
45 ☑ Cadmium (0.01)			<0.005
46 ☑ Lead (0.05)			<0.02
47 ☑ Selenium (0.01)			<0.005
48 ☑ Mercury (.005)			<0.0005
50 ☐ SPECIAL			
49 ☐ Boron			
51 ☐ Radiological			
52 ☐ Petroleum Res.			
53 ☐ C.C.E. (0.2)			
54 ☐ Phenols (0.001)			
55 ☐ Pesticides			
56 ☑ PHYSICAL			
☐ Color			
☐ Taste			
☐ Odor			
☑ Turbidity			8

☐ Acceptable for Public Usage
☐ Provisionally Accepted for Public Usage*
☐ Rejected for Public Usage*
☐ Based on Parameters Run
*See attached for interpretation
Evaluated by _____
Bureau of Water Quality Control
Date _____

D Dissolved T - Total

COMMENTS run mass balance

Analyst Barbara Olmen Date Reported 4/1/83

BWQ FILE COPY

D/DCS/Epidemiology and Laboratory Services-17 (5-76)

SPECIMEN SUBMITTING AND REPORTING FORM 1 7 (25 26)

State of Arizona
Department of Health Services
State Laboratory

Date Rec'd. [redacted] (3)

VERIFIED

J. M. COUNTS, Dr.P.H., Chief

WATER QUALITY ANALYSIS - Chemical

CODED DATE 6-4-93 BY Mune

~~SPECIMEN UNSATISFACTORY~~ Reason: _____ CODE

SPECIMEN NUMBER 1835 | SYSTEM NUMBER

17 DATE 2-24-93 BY Jm 24

NAME OF CLIENT EK Swanson | IDENTIFICATION NUMBER

ADDRESS BuRQC

CITY Phx | STATE | ZIP CODE | COUNTY | CODE (15 16)

SOURCE TYPE (check one) Ambient
☐ Well ☑ Surface ☐ Sewage ☐ Industrial ☐ Seepage

SOURCE DATA (check each applicable box)
☐ Public System ☐ Individual System
☐ Treated ☑ Untreated
☐ Routine Sample ☐ Re-Sample ☑ Special
☑ Grab Sample ☐ Composite Sample
☐ New Source ☑ Existing Source

LAB USE ONLY
Lab Performing Test
Phoenix - 1
Flagstaff - 2
Tucson - 3 (27)
DO NOT CHARGE (28)

MAILING ADDRESS OF REPORT
ADDRESS
CITY | STATE | ZIP CODE

FIELD DATA -
Conductivity 290 Mhos D.O. 14.4 pH 8.52
Air Temp. 18 °C. Water Temp. 6.8 °C
Well Depth _____ Static Water Level _____
Gage Height _____ Discharge _____ CFS
Depth to Surface _____ _____ GPM

SYSTEM OR SOURCE NAME Burro Creek | CITY Bagdad | WELL NUMBER

LOCATION OF SAMPLING POINT Burro Creek @ livestock below Francis Creek ~~WELL NAME~~

COUNTY Yavapai | TOWNSHIP | RANGE | SECTION | COLLECTED BY Pompa

LATITUDE | LONGITUDE | STATION NUMBER BC05 | DATE COLLECTED 2/14/83 | HOUR 820

STORET NUMBER | CONTROL NUMBER R038 | PRESERVATIVE ADDED? ☑ YES ☐ NO

SAMPLE APPEARANCE -
☑ Clear ☐ Turbid ☐ Silty ☐ Floating ☐ Other

WEATHER
☑ Clear ☐ Cloudy ☐ Rain ☐ Snow ☐ Other

SAMPLER'S COMMENTS: includes ortho PO4 sample

	D	T	ME/L	Mg/L
10 ☑ ROUTINE WATER CHEMISTRY				
11 ☑ Specific Resistance (OHMS)				3470 (29)
12 ☑ pH				8.0
13 ☑ CATIONS				
14 ☑ Calcium				27
15 ☐ Magnesium				8.
16 ☑ Sodium				16.4
17 ☑ Iron (0.3)				0.33
18 ☑ Copper (1.0)				<0.01
19 ☑ Manganese (0.05)				<0.05
20 ☑ Zinc (5.0)				<0.05
			Σ(+) 2.819	
21 ☑ ANIONS				
22 ☑ Alk.P (CaCO3)				0
23 ☑ Alk.MP (CaCO3)				94.6
24 ☑ Chloride (250)				7
25 ☑ Nitrate (45) NO3				0.66
26 ☑ Sulfate (250)				11.1
27 ☑ Total PO4 as P				0.07
28 ☑ Fluorides				0.28
38 ☐ Nitrite				
			Σ(-) 2.3459	

D - Dissolved T - Total

	Mg/L
29 ☐ Solids	
30 ☑ Residue	171
31 ☐ T.D.S. Calc.	
32 ☑ Hardness (CaCO3)	102
33 ☑ Total S.S.	2
34 ☐ V.S.S.	
35 ☐ Surfactants	
36 ☐ B.O.D.	
37 ☐ C.O.D.	
39 ☑ Kjeldahl Nitrogen Total	0.7
40 ☑ Others K	3.7
Si	<0.01
Fe	<0.01
SiO2 - Si	19.8

☐ Acceptable for Public Usage
☐ Provisionally Accepted for Public Usage*
☐ Rejected for Public Usage*
☐ Based on Parameters Run
*See attached for interpretation

Evaluated by _____
Bureau of Water Quality Control
Date _____

	D	T	Mg/L
41 ☑ TRACE METALS (Mg/l)			
42 ☑ Arsenic (.01) (.05)			<0.02
43 ☑ Silver (.05)			<0.005
44 ☑ Chromium (0.05)		✓	<0.01
45 ☑ Cadmium (0.01)			<0.005
46 ☑ Lead (0.05)			<0.02
47 ☑ Selenium (0.01)			<0.005
48 ☑ Mercury (.005)			<0.0005
50 ☑ SPECIAL			
49 ☑ ~~Boron~~ ortho PO4 as P			0.05
51 ☐ Radiological			
52 ☐ Petroleum Res.			
53 ☐ C.C.E. (0.2)			
54 ☐ Phenols (0.001)			
55 ☐ Pesticides			
56 ☐ PHYSICAL			
☐ Color			
☐ Taste			
☐ Odor			
☑ Turbidity			7

COMMENTS Ran mass balance

Analyst Barbara Ahmann Date Reported 2/2/83 B. Ahmann for GMC

ADHS/DCS/Epidemiology and Laboratory Services-17 (5-76)

LABORATORY COPY

CIMEN SUBMITTING REPORTING FORM | 1 | 7 | (25, 26)

State of Arizona
Department of Health Services
State Laboratory

Date Rec'd. FEB 17 5 50 AM '83 (3, 8)
J. M. COUNTS, Dr.P.H., Chief

ATER QUALITY ANALYSIS - Chemical

SPECIMEN UNSATISFACTORY
Reason: _____ CODE

MEN NUMBER: 24635 | SYSTEM NUMBER:

OF CLIENT: EK Swanson | IDENTIFICATION NUMBER: (17, 24)

ESS: BWOC

Phx | STATE | ZIP CODE | COUNTY | CODE (15, 16)

AB USE ONLY
Performing Test
enix - 1
gstaff - 2
son - 3 (27)
NOT CHARGE (28)

MAILING ADDRESS OF REPORT
ADDRESS
CITY | STATE | ZIP CODE

EM OR SOURCE NAME | CITY | WELL NUMBER

TION OF SAMPLING POINT | WELL NAME

ITY | TOWNSHIP | RANGE | SECTION | COLLECTED BY

UDE | LONGITUDE | STATION NUMBER: QC-1 | DATE COLLECTED: 2-83 | HOUR

ET NUMBER | CONTROL NUMBER | PRESERVATIVE ADDED? ☐ YES ☐ NO

SOURCE TYPE (check one)
☐ Well ☐ Surface ☐ Sewage ☐ Industrial ☐ Seepage

SOURCE DATA (check each applicable box)
☐ Public System ☐ Treated ☐ Routine Sample
☐ Individual System ☐ Untreated ☐ Re-Sample
☐ Special
☐ Grab Sample ☐ New Source
☐ Composite Sample ☐ Existing Source

FIELD DATA -
Conductivity _____ Mhos D.O. _____ pH _____
Air Temp. _____ °C. Water Temp. _____ °C.
Well Depth _____ Static Water Level _____
Gage Height _____ Discharge _____ CFS
Depth to Surface _____ _____ GPM

SAMPLE APPEARANCE -
☐ Clear ☐ Turbid ☐ Silty ☐ Floating ☐ Other

WEATHER -
☐ Clear ☐ Cloudy ☐ Rain ☐ Snow ☐ Other

SAMPLER'S COMMENTS: _____

☑ ROUTINE WATER CHEMISTRY

1	☑ Specific Resistance (OHMS)	4740
2	☑ pH	7.6

☑ CATIONS

		D	T	ME/L	Mg/L
4	☑ Calcium				22
5	☑ Magnesium				6
6	☑ Sodium				10.0
7	☑ Iron (0.3)				1.8
8	☑ Copper (1.0)				<0.01
9	☑ Manganese (0.05)				<0.05
0	☑ Zinc (5.0)				<0.05

☑ ANIONS

		D	T	ME/L	Mg/L
2	☑ Alk P (CaCO3)				0
3	☑ Alk MP (CaCO3)				67.1
4	☑ Chloride (250)				4
5	☑ Nitrate (45) - NO_3				0.62
6	☑ Sulfate (250)				12.0
7	☑ Total PO4 - P				0.18
8	☑ Fluorides				0.20
9	☐ Nitrite				

		Mg/L
29	☐ Solids	
30	☑ Residue	191
31	☐ T.D.S. Calc.	
32	☑ Hardness (CaCO3)	80
33	☑ Total S.S.	2
34	☐ V.S.S.	
35	☐ Surfactants	
36	☐ B.O.D.	
37	☐ C.O.D.	
39	☑ Kjeldahl Nitrogen Total	1.0
40	☑ Others K	3.5
	Sb	<0.01
	Mo	0.02
	SiO_2 - Si	23.4

☐ Acceptable for Public Usage
☐ Provisionally Accepted for Public Usage*
☐ Rejected for Public Usage*
☐ Based on Parameters Run
*See attached for interpretation
Evaluated by _____
Bureau of Water Quality Control
Date _____

		D	T	Mg/L
41	☑ TRACE METALS (Mg/l)			
42	☑ Arsenic (.01)(.05)			<0.02
43	☑ Silver (.05)			<0.005
44	☑ Chromium (0.05)		✓	<0.01
45	☑ Cadmium (0.01)			<0.005
46	☑ Lead (0.05)			<0.02
47	☑ Selenium (0.01)			<0.005
48	☑ Mercury (.005)			<0.0005
50	☐ SPECIAL			
49	☐ Boron			
51	☐ Radiological			
52	☐ Petroleum Res.			
53	☐ C.C.E. (0.2)			
54	☐ Phenols (0.001)			
55	☐ Pesticides			
56	☑ PHYSICAL			
	☐ Color			
	☐ Taste			
	☐ Odor			
	☑ Turbidity			22

D Dissolved T - Total

COMMENTS run mass balance

Analyst Barbara Olmeni Date Reported 4/6/83

LABORATORY COPY

DOI/DCS/Epidemiology and Laboratory Services-17 (5-76)

SPECIMEN SUBMITTING AND REPORTING FORM 17 (25, 26)

State of Arizona
Department of Health Services
State Laboratory

Date Rec'd. FEB 17 ~51 AM '83

J. M. COUNTS, Dr.P.H., Chief

WATER QUALITY ANALYSIS - Chemical

CODED 4/25 BY

VERIFIED 17 BY

SPECIMEN UNSATISFACTORY Reason: VERIFIED DATE 9-23 BY D.J.C. CODE

SPECIMEN NUMBER 24043 | SYSTEM NUMBER

NAME OF CLIENT E R Swanson DATE BY | IDENTIFICATION NUMBER

ADDRESS Bullc

CITY Phx | STATE | ZIP CODE | COUNTY | CODE 15 16

SOURCE TYPE (check one) Ambient D.J.C.
☐ Well ☑ Surface ☐ Sewage ☐ Industrial ☐ Seepage

SOURCE DATA (check each applicable box)
☐ Public System ☐ Individual System
☐ Treated ☑ Untreated
☐ Routine Sample ☐ Re-Sample ☑ Special
☑ Grab Sample ☐ Composite Sample
☐ New Source ☑ Existing Source

LAB USE ONLY
Lab Performing Test
Phoenix - 1
Flagstaff - 2
Tucson - 3
27
DO NOT CHARGE
28

MAILING ADDRESS OF REPORT

ADDRESS

CITY | STATE | ZIP CODE

FIELD DATA -
Conductivity 1914 Mhos D.O. 10.6 pH 8.23
Air Temp. 18 °C. Water Temp. 9.2 °C.
Well Depth _____ Static Water Level _____
Gage Height _____ Discharge _____ CFS
Depth to Surface _____ _____ GPM

SYSTEM OR SOURCE NAME Burro Creek | CITY Bagdad | WELL NUMBER

LOCATION OF SAMPLING POINT Burro Cr. @ livestock below Francis Cr | WELL NAME

COUNTY Yavapai | TOWNSHIP | RANGE | SECTION | COLLECTED BY Rampe

LATITUDE | LONGITUDE | STATION NUMBER 2C015 | DATE COLLECTED 24583 | HOUR 1500

STORET NUMBER | CONTROL NUMBER R009 | PRESERVATIVE ADDED? ☑ YES ☐ NO

SAMPLE APPEARANCE -
☐ Clear ☑ Turbid ☐ Silty ☐ Floating ☐ Other

WEATHER -
☐ Clear ☑ Cloudy ☐ Rain ☐ Snow ☐ Other

SAMPLER'S COMMENTS: includes ortho P4 sample

		D	T	ME/L	Mg/L
10 ☑	ROUTINE WATER CHEMISTRY				
11 ☑	Specific Resistance (OHMS)				4740
12 ☑	pH				7.8
13 ☑	CATIONS				
14 ☑	Calcium				20
15 ☑	Magnesium				7
16 ☑	Sodium				10.0
17 ☑	Iron (0.3)				2.2
18 ☑	Copper (1.0)				<0.01
19 ☑	Manganese (0.05)				<0.05
20 ☑	Zinc (5.0)				<0.05
21 ☑	ANIONS				
22 ☑	Alk P (CaCO3)				0
23 ☑	Alk MP (CaCO3)				65.5
24 ☑	Chloride (250)				4
25 ☑	Nitrate (45) NO_3				0.6
26 ☑	Sulfate (250)				12.8
27 ☑	Total PO_4 -P				0.10
28 ☑	Fluorides				0.19
38 ☐	Nitrite				

		Mg/L
29 ☐	Solids	
30 ☑	Residue	366
31 ☐	T.D.S. Calc.	
32 ☑	Hardness (CaCO3)	80
33 ☑	Total S.S.	<1
34 ☐	V.S.S.	
35 ☐	Surfactants	
36 ☐	B.O.D.	
37 ☐	C.O.D.	
39 ☑	Kjeldahl Nitrogen Total	0.8
40 ☑	Others K	3.1
	Sb	<0.01
	Mo	<0.01
	SiO_2 - Si	16.9

		D	T	Mg/L
41 ☑	TRACE METALS (Mg/l)			
42 ☑	Arsenic (.01)(.05)			<0.02
43 ☑	Silver (.05)			<0.005
44 ☑	Chromium (0.05)		✓	<0.01
45 ☑	Cadmium (0.01)			<0.005
46 ☑	Lead (0.05)			<0.02
47 ☑	Selenium (0.01)			<0.005
48 ☑	Mercury (.005)			<0.0005
50 ☑	SPECIAL			
49 ☑	Boron ortho P	-P		0.08
51 ☐	Radiological			
52 ☐	Petroleum Res.			
53 ☐	C.C.E. (0.2)			
54 ☐	Phenols (0.001)			
55 ☐	Pesticides			
56 ☑	PHYSICAL			
☐	Color			
☐	Taste			
☐	Odor			
☑	Turbidity			22

D - Dissolved T - Total

☐ Acceptable for Public Usage
☐ Provisionally Accepted for Public Usage*
☐ Rejected for Public Usage*
☐ Based on Parameters Run
*See attached for interpretation

Evaluated by _____
Bureau of Water Quality Control
Date _____

COMMENTS run mass balance

Analyst Barbara Ohmert Date Reported 4/6/83

ADHS/DCS/Epidemiology and Laboratory Services-17 (5-76)

LABORATORY COPY

SPECIMEN SUBMITTING REPORTING FORM | 1 | 7 | (25, 26)

State of Arizona
Department of Health Services
State Laboratory

Date Rec'd. FEB 18 2 16 PM '83 (8)
J. M. COUNTS, Dr.P.H., Chief

WATER QUALITY ANALYSIS - Chemical

SPECIMEN UNSATISFACTORY
Reason: _____ CODE

SPECIMEN NUMBER: 24858
SYSTEM NUMBER:
17 24
NAME OF CLIENT: E K Swanson
IDENTIFICATION NUMBER:
ADDRESS: BWQC
CITY: Pkx
STATE:
ZIP CODE:
COUNTY:
CODE: 15 16

LAB USE ONLY
Performing Test
Phenix - 1
Flagstaff - 2
Tucson - 3
27
DO NOT CHARGE
28

MAILING ADDRESS OF REPORT:
ADDRESS:
CITY:
STATE:
ZIP CODE:

SYSTEM OR SOURCE NAME:
CITY:
WELL NUMBER:
LOCATION OF SAMPLING POINT:
WELL NAME:
COUNTY:
TOWNSHIP:
RANGE:
SECTION:
COLLECTED BY: Rampe
LATITUDE:
LONGITUDE:
STATION NUMBER:
DATE COLLECTED: 2-83
HOUR:
TICKET NUMBER:
CONTROL NUMBER: QC-2
PRESERVATIVE ADDED? ☑ YES ☐ NO

SOURCE TYPE (check one) Ambient
☐ Well ☑ Surface ☐ Sewage ☐ Industrial ☐ Seepage

SOURCE DATA (check each applicable box)
☐ Public System ☐ Treated ☐ Routine Sample
☐ Individual System ☐ Untreated ☐ Re-Sample
☐ Special
☐ Grab Sample ☐ New Source
☐ Composite Sample ☐ Existing Source

FIELD DATA - none
Conductivity _____ Mhos D.O. _____ pH _____
Air Temp. _____ °C. Water Temp. _____ °C.
Well Depth _____ Static Water Level _____
Gage Height _____ Discharge _____ CFS
Depth to Surface _____ _____ GPM

SAMPLE APPEARANCE -
☐ Clear ☐ Turbid ☐ Silty ☐ Floating ☐ Other

WEATHER -
☐ Clear ☐ Cloudy ☐ Rain ☐ Snow ☐ Other

SAMPLER'S COMMENTS: quality control

1 ☑ ROUTINE WATER CHEMISTRY								41 ☑ TRACE METALS (Mg/l)	D	T	Mg/L
1 ☑ Specific Resistance (OHMS)			3230		29 ☐ Solids			42 ☑ Arsenic (.01)(.05)			<0.02
2 ☑ pH			7.9		30 ☑ Residue		232	43 ☑ Silver (.05)			<0.005
☑ CATIONS	D	T	ME/L	Mg/L	31 ☐ T.D.S. Calc.			44 ☑ Chromium (0.05)		✓	<0.01
4 ☑ Calcium				32	32 ☑ Hardness (CaCO3)		114	45 ☑ Cadmium (0.01)			<0.005
5 ☑ Magnesium				8	33 ☑ Total S.S.		<1	46 ☑ Lead (0.05)			<0.02
6 ☑ Sodium				24.3	34 ☐ V.S.S.			47 ☑ Selenium (0.01)			<0.005
7 ☑ Iron (0.3)				0.31	35 ☐ Surfactants			48 ☑ Mercury (.005)			<0.0005
8 ☑ Copper (1.0)				<0.01	36 ☐ B.O.D.			50 ☐ SPECIAL			
9 ☑ Manganese (0.05)				<0.05	37 ☐ C.O.D.			49 ☐ Boron			
10 ☑ Zinc (5.0)				<0.05	39 ☑ Kjeldahl Nitrogen Total		0.9	51 ☐ Radiological			
☑ ANIONS					40 ☑ Others K		4.3	52 ☐ Petroleum Res.			
22 ☑ Alk P (CaCO3)				0	Sb		<0.01	53 ☐ C.C.E. (0.2)			
23 ☑ Alk MP (CaCO3)				88.9	Mo		<0.01	54 ☐ Phenols (0.001)			
24 ☑ Chloride (250)				10	SiO_2 - Si		13.4	55 ☐ Pesticides			
25 ☑ Nitrate (45) - NO_3				0.4				56 ☑ PHYSICAL			
26 ☑ Sulfate (250)				27.6				☐ Color			
27 ☑ Total PO4 - P				0.06				☐ Taste			
28 ☑ Fluorides				0.7				☐ Odor			
38 ☐ Nitrite								☑ Turbidity			9

☐ Acceptable for Public Usage
☐ Provisionally Accepted for Public Usage*
☐ Rejected for Public Usage*
☐ Based on Parameters Run
*See attached for interpretation
Evaluated by _____
Bureau of Water Quality Control
Date _____

D - Dissolved T - Total

COMMENTS run mass balance

Analyst Barbara Olivieri Date Reported 4/13/83

LABORATORY COPY

AD/DCS/Epidemiology and Laboratory Services-17 (5-76)

VERIFIED

SPECIMEN SUBMITTING AND REPORTING FORM | 1 | 7 | 2-18-83 (25, 26)

State of Arizona
Department of Health Services
State Laboratory

Date Rec'd 83 4 21 (1, 2, 3, 4, 5, 6)

J. M. COUNTS, Dr.P.H., Chief

WATER QUALITY ANALYSIS - Chemical

CODED

SPECIMEN UNSATISFACTORY Reason: _____ CODE

SPECIMEN NUMBER C-10015 | SYSTEM NUMBER

17 DATE 4-25-83 BY TJM 24

NAME OF CLIENT E.K. Swanson | IDENTIFICATION NUMBER

ADDRESS BWQC

CITY Phx | STATE | ZIP CODE | COUNTY | CODE (15, 16)

LAB USE ONLY
Lab Performing Test
Phoenix - 1
Flagstaff - 2
Tucson - 3 (27)
DO NOT CHARGE (28)

MAILING ADDRESS OF REPORT

ADDRESS

CITY | STATE | ZIP CODE

SYSTEM OR SOURCE NAME Burro Creek | CITY Wickieup | WELL NUMBER

LOCATION OF SAMPLING POINT Burro Creek 1 above BLM Campground | WELL NAME

COUNTY Mohave | TOWNSHIP | RANGE | SECTION | COLLECTED BY Rampe

LATITUDE | LONGITUDE | STATION NUMBER B0111 | DATE COLLECTED 2-18-83 | HOUR 0830

STORET NUMBER | CONTROL NUMBER R040 | PRESERVATIVE ADDED? ☑ YES ☐ NO

SOURCE TYPE (check one) Ambient
☐ Well ☑ Surface ☐ Sewage ☐ Industrial ☐ Seepage

SOURCE DATA (check each applicable box)
☐ Public System ☐ Individual System
☐ Treated ☑ Untreated
☐ Routine Sample ☐ Re-Sample ☑ Special
☑ Grab Sample ☐ Composite Sample
☐ New Source ☑ Existing Source

FIELD DATA -
Conductivity 340 µ Mhos | D.O. 11.0 | pH 8.34
Air Temp. 12 °C. | Water Temp. 8.2 °C.
Well Depth _____ | Static Water Level _____
Gage Height _____ | Discharge _____ CFS
Depth to Surface _____ | _____ GPM

SAMPLE APPEARANCE -
☑ Clear ☐ Turbid ☐ Silty ☐ Floating ☐ Other

WEATHER -
☐ Clear ☑ Cloudy ☐ Rain ☐ Snow ☐ Other

SAMPLER'S COMMENTS: includes ortho P on sample

10 ☑ ROUTINE WATER CHEMISTRY
11 ☑ Specific Resistance (OHMS) 3220
12 ☑ pH 7.9

	D	T	ME/L	Mg/L
13 ☑ CATIONS				
14 ☑ Calcium				32
15 ☑ Magnesium				8
16 ☑ Sodium				24.3
17 ☑ Iron (0.3)				0.34
18 ☑ Copper (1.0)				<0.01
19 ☑ Manganese (0.05)				<0.05
20 ☑ Zinc (5.0)				<0.05
21 ☑ ANIONS				
22 ☑ Alk P (CaCO3)				0
23 ☑ Alk MP (CaCO3)				88.9
24 ☑ Chloride (250)				11
25 ☑ Nitrate (45) - NO_3				<0.4
26 ☑ Sulfate (250)				28.7
27 ☑ Total PO4 - P				0.06
28 ☑ Fluorides				0.7
38 ☐ Nitrite				

D - Dissolved T - Total

	Mg/L
29 ☐ Solids	
30 ☑ Residue	216
31 ☐ T.D.S. Calc.	
32 ☑ Hardness (CaCO3)	114
33 ☑ Total S.S.	<1
34 ☐ V.S.S.	
35 ☐ Surfactants	
36 ☐ B.O.D.	
37 ☐ C.O.D.	
39 ☑ Kjeldahl Nitrogen Total	0.8
40 ☑ Others K	4.3
Si	<0.01
Mg	<0.01
SiO_2 - Si	14.0

☐ Acceptable for Public Usage
☐ Provisionally Accepted for Public Usage*
☐ Rejected for Public Usage*
☐ Based on Parameters Run
*See attached for interpretation

Evaluated by _____
Bureau of Water Quality Control
Date _____

	D	T	Mg/L
41 ☑ TRACE METALS (Mg/l)			
42 ☑ Arsenic (.01) (.05)			<0.02
43 ☑ Silver (.05)			<0.005
44 ☑ Chromium (0.05)		✓	<0.01
45 ☑ Cadmium (0.01)			<0.005
46 ☑ Lead (0.05)			<0.02
47 ☑ Selenium (0.01)			<0.005
48 ☑ Mercury (.005)			<0.0005
50 ☑ SPECIAL			
49 ☑ Boron ortho PO_4 - P			0.06
51 ☐ Radiological			
52 ☐ Petroleum Res.			
53 ☐ C.C.E. (0.2)			
54 ☐ Phenols (0.001)			
55 ☐ Pesticides			
56 ☑ PHYSICAL			
☐ Color			
☐ Taste			
☐ Odor			
☑ Turbidity			9.5

COMMENTS run mass balance

Analyst Barbara Ahmann Date Reported 4/11/83

ADHS/DCS/Epidemiology and Laboratory Services-17 (5-76)

LABORATORY COPY

SPECIMEN SUBMITTING AND REPORTING FORM | 1 | 7 (25, 26)

State of Arizona
Department of Health Services
State Laboratory

Date Rec'd. FEB 10 2 16 PM '83

J. M. COUNTS, Dr.P.H., Chief

WATER QUALITY ANALYSIS - Chemical

SPECIMEN UNSATISFACTORY
Reason: _____ CODE

SPECIMEN NUMBER: 24859 | SYSTEM NUMBER:

NAME OF CLIENT: E K Swanson | IDENTIFICATION NUMBER (17–24):

ADDRESS: BWQC

CITY: Ph | STATE: | ZIP CODE: | COUNTY: | CODE (15–16):

LAB USE ONLY
Lab Performing Test
Phoenix - 1
Flagstaff - 2
Tucson - 3
27

DO NOT CHARGE 28

MAILING ADDRESS OF REPORT:
ADDRESS:
CITY: | STATE: | ZIP CODE:

SYSTEM OR SOURCE NAME: | CITY: | WELL NUMBER:

LOCATION OF SAMPLING POINT: | WELL NAME:

COUNTY: | TOWNSHIP: | RANGE: | SECTION: | COLLECTED BY: Rampe

LATITUDE: | LONGITUDE: | STATION NUMBER: | DATE COLLECTED: 2-83 | HOUR:

STREET NUMBER: | CONTROL NUMBER: QC-3 | PRESERVATIVE ADDED? ☑ YES ☐ NO

SOURCE TYPE (check one) Ambient
☐ Well ☑ Surface ☐ Sewage ☐ Industrial ☐ Seepage

SOURCE DATA (check each applicable box)
☐ Public System ☐ Treated ☐ Routine Sample
☐ Individual System ☑ Untreated ☐ Re-Sample
☑ Grab Sample ☐ New Source ☑ Special
☐ Composite Sample ☑ Existing Source

FIELD DATA - none
Conductivity _____ Mhos D.O. _____ pH _____
Air Temp. _____ °C. Water Temp. _____ °C.
Well Depth _____ Static Water Level _____
Gage Height _____ Discharge _____ CFS
Depth to Surface _____ _____ GPM

SAMPLE APPEARANCE -
☐ Clear ☐ Turbid ☐ Silty ☐ Floating ☐ Other

WEATHER -
☐ Clear ☐ Cloudy ☐ Rain ☐ Snow ☐ Other

SAMPLER'S COMMENTS: quality control

☑ ROUTINE WATER CHEMISTRY
☑ Specific Resistance (OHMS) 3270
☑ pH 7.9

CATIONS	D	T	ME/L	Mg/L
Calcium				32
Magnesium				8
Sodium				24.3
Iron (0.3)				0.3
Copper (1.0)				<0.01
Manganese (0.05)				<0.05
Zinc (5.0)				<0.05

ANIONS	D	T	ME/L	Mg/L
Alk P (CaCO3)				0
Alk MP (CaCO3)				88.9
Chloride (250)				11
Nitrate (45) -NO3				0.4
Sulfate (250)				27.4
Total PO4 -P				0.06
Fluorides				0.7
Nitrite				

	Mg/L
29 ☐ Solids	
30 ☑ Residue	229
31 ☐ T.D.S. Calc.	
32 ☑ Hardness (CaCO3)	114
33 ☑ Total S.S.	1
34 ☐ V.S.S.	
35 ☐ Surfactants	
36 ☐ B.O.D.	
37 ☐ C.O.D.	
39 ☑ Kjeldahl Nitrogen Total	0.9
40 ☑ Others K	4.3
Sb	<0.01
Mo	<0.01
SiO2 - Si	13.4

TRACE METALS (Mg/l)	D	T	Mg/L
41 ☑			
42 ☑ Arsenic (.01)(.05)			<0.02
43 ☑ Silver (.05)			<0.005
44 ☑ Chromium (0.05)		✓	<0.01
45 ☑ Cadmium (0.01)			<0.005
46 ☑ Lead (0.05)			<0.02
47 ☑ Selenium (0.01)			<0.005
48 ☑ Mercury (.005)			<0.0005
50 ☐ SPECIAL			
49 ☐ Boron			
51 ☐ Radiological			
52 ☐ Petroleum Res.			
53 ☐ C.C.E. (0.2)			
54 ☐ Phenols (0.001)			
55 ☐ Pesticides			
56 ☑ PHYSICAL			
☐ Color			
☐ Taste			
☐ Odor			
☑ Turbidity			8.5

☐ Acceptable for Public Usage
☐ Provisionally Accepted for Public Usage*
☐ Rejected for Public Usage*
☐ Based on Parameters Run
*See attached for interpretation

Evaluated by _____
Bureau of Water Quality Control
Date _____

D Dissolved T - Total

COMMENTS run mass balance

Analyst Barbara Ohmen Date Reported 4/13/83

LABORATORY COPY

ADS/DCS/Epidemiology and Laboratory Services-17 (5-76)

SPECIMEN SUBMITTING AND REPORTING FORM 17 (25 26)

State of Arizona
Department of Health Services
State Laboratory
C. M. COUNTS, Dr.P.H., Chief

Date Rec'd. FEB 2 1983

WATER QUALITY ANALYSIS - Chemical

CODED 4-25-83 BY TOM

VERIFIED 9-22-83 BY M.C.

SPECIMEN UNSATISFACTORY Reason: _____ CODE

SPECIMEN NUMBER	SYSTEM NUMBER
23854	

DATE 17 24

NAME OF CLIENT: EK Swanson — IDENTIFICATION NUMBER:

ADDRESS: BuQC

CITY	STATE	ZIP CODE	COUNTY	CODE (15 16)
Phx				

SOURCE TYPE (check one) ambient
☐ Well ☑ Surface ☐ Sewage ☐ Industrial ☐ Seepage

SOURCE DATA (check each applicable box)
☐ Public System ☐ Individual System
☐ Treated ☑ Untreated
☐ Routine Sample ☐ Re-Sample ☑ Special
☑ Grab Sample ☐ Composite Sample
☐ New Source ☑ Existing Source

LAB USE ONLY
Lab Performing Test
Phoenix - 1
Flagstaff - 2
Tucson - 3
27
DO NOT CHARGE
28

MAILING ADDRESS OF REPORT
ADDRESS
CITY | STATE | ZIP CODE

FIELD DATA -
Conductivity 360.4 Mhos D.O. 11.0 pH 8.41
Air Temp. 12 °C. Water Temp. 8.4 °C.
Well Depth _____ Static Water Level _____
Gage Height _____ Discharge _____ CFS
Depth to Surface _____ _____ GPM

SAMPLE APPEARANCE -
☑ Clear ☐ Turbid ☐ Silty ☐ Floating ☐ Other

WEATHER -
☐ Clear ☑ Cloudy ☐ Rain ☐ Snow ☐ Other

SAMPLER'S COMMENTS: includes ortho PO4 sample

SYSTEM OR SOURCE NAME	CITY	WELL NUMBER
Burro Creek	Wickieup	

LOCATION OF SAMPLING POINT: Burro Creek below BLM C-G

COUNTY	TOWNSHIP	RANGE	SECTION	COLLECTED BY
Mohave				Rumpe

LATITUDE	LONGITUDE	STATION NUMBER	DATE COLLECTED	HOUR
		BC10	2-18-83	0900

STORET NUMBER	CONTROL NUMBER	PRESERVATIVE ADDED?
	R042	☑ YES ☐ NO

	D	T	ME/L	Mg/L
10 ☑ ROUTINE WATER CHEMISTRY				
11 ☑ Specific Resistance (OHMS)				3210
12 ☑ pH				7.9
13 ☑ CATIONS				
14 ☑ Calcium				32
15 ☑ Magnesium				8
16 ☑ Sodium				24.3
17 ☑ Iron (0.3)				0.31
18 ☑ Copper (1.0)				<0.01
19 ☑ Manganese (0.05)				<0.05
20 ☑ Zinc (5.0)				<0.05
21 ☑ ANIONS				
22 ☑ Alk P (CaCO3)				0
23 ☑ Alk MP (CaCO3)				90.5
24 ☑ Chloride (250)				10
25 ☑ Nitrate (45) NO_3				0.4
26 ☑ Sulfate (250)				28.0
27 ☑ Total PO4 - P				0.06
28 ☑ Fluorides				0.7
38 ☐ Nitrite				

	Mg/L
29 ☐ Solids	
30 ☑ Residue	224
31 ☐ T.D.S. Calc.	
32 ☑ Hardness (CaCO3)	114
33 ☑ Total S.S.	2
34 ☐ V.S.S.	
35 ☐ Surfactants	
36 ☐ B.O.D.	
37 ☐ C.O.D.	
39 ☑ Kjeldahl Nitrogen Total	0.8
40 ☑ Others K	4.2
Sb	<0.01
Mo	<0.01
SiO_2 - Si	13.4

	D	T	Mg/L
41 ☑ TRACE METALS (Mg/l)			
42 ☑ Arsenic (.01) (.05)			<0.02
43 ☑ Silver (.05)			<0.005
44 ☑ Chromium (0.05)		✓	<0.01
45 ☑ Cadmium (0.01)			<0.005
46 ☑ Lead (0.05)			<0.02
47 ☑ Selenium (0.01)			<0.005
48 ☑ Mercury (.005)			<0.0005
50 ☑ SPECIAL ortho PO4 - P			0.05
49 ☑ Boron			
51 ☐ Radiological			
52 ☐ Petroleum Res.			
53 ☐ C.C.E. (0.2)			
54 ☐ Phenols (0.001)			
55 ☐ Pesticides			
56 ☑ PHYSICAL			
☐ Color			
☐ Taste			
☐ Odor			
☑ Turbidity			8.7

D - Dissolved T - Total

☐ Acceptable for Public Usage
☐ Provisionally Accepted for Public Usage*
☐ Rejected for Public Usage*
☐ Based on Parameters Run
*See attached for interpretation

Evaluated by _____
Bureau of Water Quality Control
Date _____

COMMENTS Cation mass balance

Analyst Barbara Ahmann Date Reported 4/11/83

ADHS/DCS/Epidemiology and Laboratory Services-17 (5-76)

LABORATORY COPY

[illegible]

* Note Al values

! = not analyzed

June, 1982

lyses of water from seep at base of upper Hillside
ilings. Cyprus-Bagdad analyses done by Dr. Robt. Magler
t Univ. of Colorado, using ICP, AA, and ion
l [illegible]tography. All values in mg/L.

[illegible]	ADHS raw &/or acidified	C-B raw	C-B acidified
Ca	94	332	336
Mg	251	231	232
Na	127	121	126
K	1	NA.	<2.5
Fe	206	206	209
Co	40	38	39
Mn	90	90	89
Zn	324	337	338
Sb	0.08	NA.	NA
Mo	0.28	NA.	0.5
As	1.7	1.9	1.9
Ag	0.01	NA	NA.
Cr	0.07	0.1	0.1
Cd	0.03	1.0	1.0
Pb	<0.02	0.02	0.02
Se	0.01	0.07	0.07
Hg	<0.0005	N.A.	NA
Si	92	NA	120
*Al	NA	NA.	*192
Sr	N.A	N.A	0.8
Ba	N.A.	N.A.	<0.1
Co	N.A.	N.A	1.6
Li	N.A.	N.A	<1.0
Ni	N.A.	1.0	0.9
B	N.A	0.8	0.8
[illegible]	0	N.A	N.A
Cl	70	71	73
NO_3	0.09	<1.0	N.A
NO_2	<0.01	<2.5	<2.5
PO_4	<0.05	<1.0	<1.0
SO_4	3960	3970	4000
Br	NA	<0.5	NA
F	0.7	29	24
CN	NA	<0.1	NA

(?) = indicates results not yet final.
These will be redetermined.
Nof. = not filtered. All other values are filtered.

C-B = Cyprus-Exag
ADHS = Arizona Dept. Hea Servic

Trace metals comparisons µg/L

June, 1982

Sample	Location	Collector	Fe	Cu	Mn	Zn	As	Cr	Cd	Pb	Mo	Sb
RW-31 Standard Known / Found	EPA #476E (HNO_3 matrix)	C-B	78 / 94	37 / 54	47 / 53	26 / 23	61 / 68	65 / 76		113 / 120		
RW-29 & RW-30 Standards Known / Found	Runnells ($Na-Ca-SO_4$ matrix)	C-B	100 / 126 + 140	50 / 58+60	200 / 230+240	100 / (?)	50 / 48+50	50 / 73+73			50 / (?)	50 / 42+4
BC-014	Mouth of Burro Crk.	C-B (filter)	<5	<5	<5	0.4(?)	10	<5		<5	<5(?)	<1(?)
		(filter) ADHS	NF <100	NF <50	NF <50	NF <50	<20	<10	<5	<20	NF <10 / <10	NF <10 / <10
BC-021	Boulder Crk. near junction with Burro Crk.	C-B (filter)	<5	<5	66	18(?)	13	<5		<5	<5(?)	<1(
		ADHS (filter)	NF <100	NF <50	NF 100	NF <50	NF 30 / 20	NF <10 / 10	<5	<20	NF 47 / 45	NF 10 / <10
BC-042	Copper Creek monitoring well.	C-B (filter)	98	<5	200	16(?)	21	<5		<5	<5(?)	<1(?
		ADHS (filter)	NF <100	NF <50	NF 210	NF <50	NF 40 / 33	<10	<5	<20	NF 68 / 25	NF 42 / 12
BC-027	Boulder Crk at Butte Crk	C-B (filter)	<5	<5	10	15(?)	16	<5		<5	<5(?)	<1(?)
		ADHS (filter)	NF <100	NF <50	NF 180	NF 210	NF 40 / 30	NF <10 / <10	<5	<20	NF <10 / 28	NF <10 / <10
R-27	Boulder Crk. below Wilder (near ADHS 28.7 site)	C-B (filter)	<5	<5	100	8(?)	16	<5		<5	<5(?)	<1(?)
BC-28.7	Boulder Crk. above Hillside.	ADHS (filter)	NF <100	NF <50	NF 190	NF <50	NF 20 / 20	NF <10 / 20	<5	<20	NF 25 / 13	NF <10 / <10
BC-033	Francis Crk.	C-B (filter)	<5	<5	<5	15(?)	6	<5		<5	<5(?)	<1(?)
		ADHS (filter)	NF <100 / <100	NF 80 / <50	NF 60 / <50	NF 280 / <50	NF <20 / <20	NF <10 / <10	<5	<20	NF 20 / <10	NF <10 / <10
BC-017	Burro Crk. above Francis Crk.	C-B (filter)	<5	<5	<5	4(?)	7	<5		<5	<5(?)	<1(?)
		ADHS (filter)	NF <100 / <100	NF <50 / <50	NF <50 / <50	NF <50 / <50	NF <20 / <20	NF <10 / <10			NF 42 / <10	NF <10 / <10

ugust sampling trip – comparison of results

Note: All cation values reported for Cyprus-Bagdad samples are for filtered waters. Only partial results are available for ADHS filtered waters. Results for ADHS "total" (unfiltered) samples are given here in [square brackets] for comparison. All anion results are for unfiltered waters.

	* Blind standards (2)		BC 013 (Lower Burro)		BC 014 (Burro above Boulder)		BC027 (Boulder at Butte)		BC042 (Well on Copper Cr.)	
	Known	Found	Cyprus-Bagdad	ADHS	Cyprus-Bagdad	ADHS	Cyprus-Bagdad	ADHS	Cyprus-Bagdad	ADHS
, ug/L	20; 20	28; 29	<5	<10	<5	<10	<5	<10	<5	<10
, "	50; 50	60, 61	14	<100	30	<100	12	<10	1700	1120
, "	20; 20	27; 27	6	<10	<5	10	<5	<10	25	10
, "	20; 20	18; 18	<1	13	<1	10	<1	<10	<1	11
, "	20; 20	17; 17	20	24	30	34	30	39	160	130
, "	20; 20	20; 19	8	<10	5	<10	31	29	34	63
, "	50; 50	55; 57	22	<50	11	<50	312	290	96	70
, "	50; 50	51; 49	<2	<50	<2	<50	<2	<50	222	190
, mg/L	300; 300	315; 315	54	[50]	36	[34]	50	[44]	252	[231]
, "	0; 0	0.09; 0.09	24	[26]	21	[21]	20	[21]	93	[96]
, "	240; 240	218; 223	78	[89]	97	[109]	61	[68]	173	[175]
, "	0; 0	<0.05; <0.05	8	[10]	9	[13]	5	[7]	140	[20]
4, mg/L	–	–	99	79	48	32	79	71	986	968
, "	–	–	61	51	65	56	31	23	68	60
(CaCO3)	–	–	232	219	277	252	210	193	182	168
S (180°C)	–	–	491	538	502	456	404	379	1819	1744

* The standard solution was made up to simulate the Na Ca-SO_4 matrix of Boulder Creek waters. Bicarbonate was also present. One liter of standard solution was split into two portions and submitted to the lab as an unknown.

ADHS = Arizona Dept. Health Services
CBC = Cyprus Bagdad Co. (Runnells - Water Resources)
R = raw water
F = filtered

October, '82 sampling

Components, in mg/L

Sample No. & location		Na	K	Ca	Mg	Cu	Zn	Mn	Cr	Mo	Co	Fe	Furnace Sb	As	SO_4	Cl	Alkal.	TDS (180°C)
BC-013	ADHS-R	57.2	7.6	39	18	0.012	<0.05	<0.05	<0.01	<0.01	-	0.14	<0.01	<0.02	47.6	28	160.7	345
Burro Creek	ADHS-F	-	-	-	-	<0.01	<0.05	<0.05	<0.01	0.01	-	<0.10	<0.01	<0.02	72.4	35.4	220	470
below Boulder	CBC-R	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Creek)	CBC-F	50	6.8	33	21	<0.005	0.003	0.009	<0.005	0.004	<0.01	<0.001	<0.03	0.016	-	-	-	-
BC-027																		
Boulder Creek	ADHS-R	94.4	6.9	40	19	0.017	<0.05	0.16	<0.01	0.04	-	0.18	<0.01	0.026	87.9	29	200.1	440
at Butte	ADHS-F	-	-	-	-	<0.01	<0.05	0.07	<0.01	0.04	-	<0.10	<0.01	0.025	-	-	-	-
Creek)	CBC-R	-	-	-	-	-	-	-	-	-	-	-	-	-	100	39.2	270	460
	CBC-F	84	5.9	33	23	<0.005	0.010	0.16	<0.005	0.032	<0.01	0.003	<0.001	0.023	-	-	-	-
BC-042																		
Observation	ADHS-R	182.2	21.0	224	70	4.8	1.56	0.17	<0.01	0.023	-	124.	0.02	4.31	922	61	170.6	1704
well in	ADHS-F	-	-	-	-	<0.01	0.27	<0.05	<0.01	0.038	-	1.51	<0.01	0.141	-	-	-	-
Copper Creek)	CBC-R	-	-	-	-	-	-	-	-	-	-	-	-	-	910	67.6	230	1700
	CBC-F	170	18	210	80	<0.005	0.31	0.13	<0.005	0.025	0.01	11.	0.059	1.9	-	-	-	-

Results of December Sampling (Mg, Ca, Na, K, Cr, Mo, Sb (Furnace), Sb (hydride), Mn, Zn, Cu, As, Fe)

All Samples filtered except as indicated. WR = Water Resources. ADHS = Ariz. Dept. of Health Services

Sample No.	Alkal. ($CaCO_3$)	SO_4	TDS (105°C)	Cl	Component, mg/L													
					Mg	Ca	Na	K	Cr	Mo	Sb (Furnace)	Sb (hydride)	Mn	Zn	Cu	As	Fe	
WR-BC013	68	23.3	132	5.2	5.0	13	7.3	2.1	<0.005	<0.002	<0.01	<0.001	0.010	0.007	0.005	0.004	~~0.37~~ 0.34	
									[<0.005]					[<0.005]	[0.01]			
ADHS-BC-013									<0.01	<0.01	<0.01		<0.05	0.10 ====	<0.01	<0.02	0.13	
WR-BC-021	36	26.3	105	3.7	4.0	11	5.3	1.6	<0.005	<0.002	<0.01	<0.001	0.014	0.008	0.006	.004	0.22	
									[<0.005]					[<0.005]	[0.026]			
ADHS-BC-021									<0.01	<0.01	<0.01		<0.05	0.12 =====	<0.01	<0.02	0.16	
WR-BC-025.5	185	1300	2100	85.7	140	380	79	5.0	<0.005	0.005	<0.01	<0.001	0.18	0.002	<0.005	0.005		
									[<0.005]					[0.011]	[0.009]		0.024	
ADHS-BC-025.5 (not filtered)	146.1	1323	2199	60	120	368	82.8	6.5	<0.01	0.010	<0.01		0.18	<0.05	<0.01	<0.02		
																	0.13	
WR-BC-027	37	20.3	80	7.0	3.4	10	6.6	1.3	<0.005	<0.002	<0.01	<0.001	0.022	0.013	<0.005	0.007		
									[0.005]					[0.017]	[0.012]		0.21	
ADHS-BC-027									<0.01	<0.01	<0.01		<0.05	<0.05	<0.01	<0.02	0.23	
WR-BC-029	22	16.5	81	4.7	2.4	7.4	3.3	1.0	<0.005	<0.002	<0.01	<0.001	0.007	0.003	<0.005	<0.001		
									[0.006]					[<0.005]	[<0.005]		0.25	
ADHS-BC-029									<0.01	<0.01	<0.01		<0.05	<0.05	<0.01	<0.02	0.20	
WR-BC-042	188	1170	1900	92.8	100	280	130	20	<0.005	0.027	<0.01	<0.001	0.12	0.56	<0.005	0.087		
									[0.006]					[0.54]	[<0.005]		0.69	
		[1164]				[253]	[162]		[<0.005]					[0.5]	[<0.005]			
ADHS-BC-042									<0.01	0.031	<0.01		0.11	0.37	<0.01	0.059	0.053	

[ ] = Results from University of Colorado laboratory, Center for Environmental Science

Discrepancy between ADHS and Water Resources Results

APPENDIX C

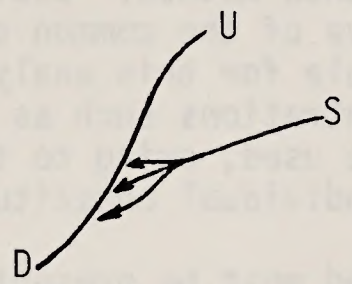
Methodology of determining stream, spring, and alluvial flows using ion loading techniques.

Introduction

Ion loadings can be extremely useful in approximating streamflows in water quality studies such as the one performed in the Burro Creek drainage. The technique is used when two waters with recognizably different chemistries meet and mix. The primary advantage of this method is that it provides an accurate approximation of flow emanating from sources that are not readily quantified by conventional measuring techniques, such as spring galleries and subterranean alluvial inflow. Ion loadings also provide a means whereby conventional discharge measurements may be verified.

Principles and assumptions

When two waters meet and mix, as shown below, the resultant chemistry at the point of complete mixing ideally represents the flow-weighted average of the chemistries of the two source waters (deviations from the ideal occur more often than not, for reasons to be discussed). In this example, U is an



upstream site in a river, D is a downstream site where complete mixing has occurred, and S is a source of chemically distinct water entering the river, such as from a stream, springs, or pollutant discharge. An ion (I) occurs in the waters at point S in differing quantities (in mg/l) than at point U. The following relationship among ion loads at the three sites results:

$$Flow_D \times I_D = (Flow_U \times I_U) + (Flow_S \times I_S), \text{ where} \qquad (1)$$

$Flow_{D,U,S}$ = streamflow at points D, U, and S, and

$I_{D,U,S}$ = the concentration of ion I at points D, U, and S.

If the concentration of I is known at all three points, and the flow at point D is assumed to result solely from the flows at points U and S, flow at point D may be set to 1.00 (or 100%) resulting in the following one-variable equation:

$$1.00 \times I_D = (X \times I_U) + (1.00-X)(I_S), \qquad (2)$$

where X = streamflow at point U,

and 1.00-X= streamflow at point S.

Thus, the proportions of flow at the downstream point D resulting from each of the two upstream waters can be derived even when no discharge measurements are available (this method was used in the report to determine the seasonal per cent dependence of Boulder Creek on waters emanating from Black Mesa Gulch). If discharge at one of the three points is known, discharge at the other two points is readily arrived at when the proportions in equation (2) are solved.

Several assumptions are implicit in this method, resulting in criteria which should be adhered to as rigorously as possible if the results of an ion balance analysis are to be reliable:

1. The tracer ion (I) selected for the analysis should be physicochemically and biologically conservative, and not engage in processes that would serve to limit its mobility in surface waters. Simple dilution should be the primary means by which concentrations of the tracer ion are determined in the system. Ions such as metals, silica, and nitrogen and phosphorus nutrients are subject to removal via precipitation and biological uptake; in most cases dilution is relatively unimportant in determining their concentrations in natural waters. As such, they are unsuited for this type of analysis. Chloride and fluoride are the most mobile of the common anions and are well-suited to the ion balance method. Sodium is the most chemically conservative of the common cations, and may be the only one suitable for this analysis. Aggregate measures of ion concentrations such as TDS and specific conductance may not be used, owing to the varying chemical properties of their individual constituents.

2. The tracer ion selected must be present in recognizably different concentrations in the constituent waters. If the mixing waters are identical with respect to concentrations of the tracer ion, no analysis is possible. In general, the greater the disparity in concentrations of the tracer ion in the constituent waters, the more reliable the analysis will be. A high degree of precision in determining tracer ion concentration will allow ion balance calculations to proceed in cases where the difference in concentrations in the mixing waters is small. Thus, the ideal tracer ion is mobile, occurs in recognizably differing quantities, and can be determined with a high degree of analytical precision.

3. No significant unknown sources of water can be present. In desert streams, the most probable situation where this kind of error could occur would be that where undetected alluvial water at point U comprised a major portion of the surface flow at point D. While there is no way of completely ruling out such contributions, the field investigator can minimize their probability of occurrence by choosing instream monitoring points that appear hydrologically similar, and by avoiding stations that have intervening areas of possible hydrologic significance such as (apparently) dry washes.

The ion-balance method of determining streamflow or streamflow proportions should not be relied upon exclusively to provide discharge measurements. It provides a reliable check on standard measures of discharge, and provides a simple method whereby streamflow may be derived in situations where standard measurements are difficult or impossible. Measurements derived by ion balance methodology are often more precise than direct measurements, and provide a useful tool for the understanding of hydrologic and geochemical cycling in streams.

ERRATA

The following errors and omissions occur in the Final Report:

1. In Figure 12, page 61, sites labelled "BC040, 041" should be labelled "BC041, 042."

2. The table describing physicochemical characteristics of artesian water emanating from a drill hole in Cyprus-Bagdad's East Pit (site BC045, page 122) was omitted. It appears on the following sheet.

3. Results of sampling for dissolved heavy metals were not included in Table 17, page 132, and subsequent tables summarizing water quality. These results were excluded because dissolved metals rarely appeared above detection limits at these sites, and never violated State surface water quality standards. A summary of dissolved heavy metal occurrence for these sites follows:

Site	Metal	Concentration (ug/l), date
BC010	Cu	10, 2/83
	Fe	100, 2/83
	Mo	13, 4/82; 16, 6/82; 14, 8/82; 13, 10/82
BC011	Fe	100, 2/83
	Mo	13, 4/82; 13, 6/82; 11, 8/82, 15, 10/82
	Sb	11, 8/82
BC013	Fe	290, 2/83
	Mo	11, 4/82; 10, 10/82
	Sb	13, 8/82
BC014	Fe	340, 2/83
	Sb	10, 8/82
BC020, 021	Fe	240, 2/82; 160, 2/83
	Cu	20, 2/83
	Cr	10, 6/82
	Mo	43, 4/82; 45, 6/82; 40, 2/83
BC023	Fe	130, 2/82; 160, 12/82; 290, 2/83
	Cu	20, 2/83
	Mo	15, 12/82

Complete results for all water quality samples are presented in Appendix A of the Final Report.

Water quality characteristics of site BC045, artesian water emanating from a drill hole in the Cyprus-Bagdad East Pit. All quantities total mg/l except where noted. Results from a single sample collected 2/11/82; complete analyses not performed.

Parameter	Result
H_2O temperature (^oC)	34.0
Specific conductance (μmhos/cm)	490
pH (standard units)	7.40
Ca	39
Mg	3
Na	59
K	3
Cl	13
F	2.16
As	<0.020
Cd	<0.005
Cr	<0.050
Cu	<0.050
Fe	0.090
Pb	<0.020
Mn	<0.050
Mo	0.030
Ag	<0.050
Zn	<0.050
Sb	0.010
Se	<0.005
Hg	<0.002